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VOLUME 13 NOVEMBER, 1939 NUMBER 6

FAUNA OF THE NIAGARAN NODULES OF THE CHICAGO AREA

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ABSTRACT—Nodules consisting of nuclei of siliceous fossils in a matrix of calcium carbonate occur in the Niagaran dolomite near Chicago. The nodules contain an invertebrate fauna of small individuals comprising 52 genera and 66 species of which 9 genera and 34 species are herein described as new.

SILICEOUS NODULES are common in exposures of the Niagaran dolomite in the many quarries in and adjacent to Chicago. Another type of nodule, which was discovered in 1930, consists of numerous silicified fossils, intermeshed and embedded in a matrix dominantly of calcium carbonate. These structures are spheroidal in character, commonly depressed-elliptical in section, and range in maximum dimensions from about 5 to 20 centimeters. The mode of their origin has been postulated in a previous paper.[1]

Investigation of the available outcrops has yielded a single occurrence of the nodules. This is in a restricted zone, 52 feet below the top of the dolomite as exposed in the Federal Stone Company quarry at the western limits of Chicago. The nodules have a vertical extent of about 3 feet and a sporadic lateral occurrence of about 400 feet.

For this study the siliceous fossils were removed from the nodule matrix by digestion with dilute acid. Most of the forms have been replaced by silica in such manner that the details of their structure are well preserved, but in some groups, notably the bryozoans, the microscopic wall structure has been obliterated and specific determinations are impossible. Altogether, the fauna comprises 52 recognized genera and 66 species of which 9 genera and 34 species are herein described as new. In addition there is much fragmental material, dominantly echinodermal, which has not been included in the above recapitulation. For the sake of brevity, only new species are included in the descriptive portion of the paper, but in addition the following Silurian forms have been recognized in the fauna:

Thurammina irregularis Moreman
Thurmammina arcuata Moreman
Pycnostylus? sp.
Spirorbis inornatus Hall
Troostocrinus reinwardti (Troost)
Parmorthis waldronensis (Foerste)
Rhipidomella hybrida (Sowerby)
Anastrophia internascens Hall
Pentamerus oblongus Sowerby
Conchidium laqueatum (Conrad)
Rhynchotrela cuneata americana (Hall)
Camarotoechia indianensis (Hall)
Atrypa nodostriata Hall
Delthyris crispus (Hisinger)
Spirifer radiatus (Sowerby)
Meristina cf. *maria* (Hall)
Whitfieldella cf. *nitida* (Hall)
Whitfieldella cylindrica (Hall)
Conocardium niagarense Winchell & Marcy
Strophostylus cyclostomus Hall
Diaphorostoma niagarense (Hall)
Actinoceras? sp.

Since the fauna includes a relatively great number of new species and few diag-

[1] Croneis, Carey, and Grubbs, D. M., 1939, Silurian Sea Balls: *Jour. Geology*, vol. 47

nostic previously described forms, it is difficult to arrive at any definite conclusions as to the correlative position of the nodules. There is, however, a resemblance between the assemblage of the nodules and that of the Racine dolomite in the adjacent areas. Several of the species common to the two faunas are identical in all respects except in size, and with few exceptions the forms in the nodules are from one-third to one-half the size of the Racine species. Otherwise the individuals have all of the characteristics of mature species.

All of the material herein described comes from a nodular zone in the Federal Stone Company quarry near Chicago.

Holotypes and paratypes are deposited in the Walker Museum of Paleontology, University of Chicago.

The writer is indebted to Dr. Carey Croneis, Walker Museum, University of Chicago, for his direction and assistance in preparation of this manuscript.

SYSTEMATIC DESCRIPTIONS

Phylum PROTOZOA

Order FORAMINIFERA

Family RHIZAMMINIDAE

Genus ARENOSIPHON Grubbs, n. gen.

Test free, cylindrical, rarely branching, commonly tapering slightly, straight or slightly curved, occasionally constricted at intervals; wall of medium to fine sand grains, firmly cemented; surface rough; apertures at ends of tube.

Genotype, *Arenosiphon gigantea* Grubbs, n. sp.

Remarks.—This genus has been erected to include a large foraminifer which occurs abundantly in the nodules. It differs from other genera of the family in its generally large size and in that the test was formed by selection of apparently only quartz grains of nearly uniform size, a rough surface resulting. Several small Silurian forms, which have been referred to the genus *Bathysiphon* by some workers, possibly belong here.

ARENOSIPHON GIGANTEA Grubbs, n. sp.

Plate 61, figures 1–3

Test free, generally large, cylindrical, rarely branching, commonly tapering uniformly or irregularly, straight or in most cases somewhat curved, in some cases constricted externally; wall of medium to fine quartz grains, firmly cemented; surface rough; apertures circular, at one or both ends of the tubes, occasionally of smaller diameter than maximum of tube.

Dimensions of holotype: length, 12.0 mm; greatest diameter, 0.9 mm; average of several specimens: length, 14.0 mm; diameter, 1.0 mm.

Holotype, no. 46000; paratypes, no. 46001.

Remarks.—This species is characterized by its relatively large size, by the type of material of the test, and by the surface texture.

Family STEGNAMMINIDAE

Genus SOROSPHAERA H. B. Brady, 1897

SOROSPHAERA IRREGULARIS Grubbs, n. sp.

Plate 61, figure 4

Test free, composed of two or more subspherical chambers in a single plane, chambers attached but not communicating with each other, flattened at the junctions and in some cases slightly flattened on one or more sides; wall thin, composed of fine sand with much cement; surface smooth except for a few short spines; apertures not apparent.

Dimensions of holotype: length of test, 1.1 mm; diameter of individual cell, 0.25 mm.

Holotype, no. 46002; paratypes, no. 46003.

Remarks.—This form is related to *S. tricella* Moreman and other Silurian species. Several species have been erected in which the determination apparently was based on the number of cells, but from the material at hand it is evident that a rupture of some of the composite individuals would obviously produce several new ones having variable numbers of chambers. Thus, a specific description would possibly apply to only a single individual. Forms of such variable attributes are here grouped into one species.

Family SACCAMMINIDAE

Genus LAGENAMMINA Rhumbler, 1911

LAGENAMMINA CORNUTA Grubbs, n. sp.

Plate 61, figures 5, 6

Test free, subspherical; neck short, hornlike, tapering, producing asymmetry by an

undulation in the test on the concave side of the neck; wall thick, composed of fine sand grains, well cemented; surface rough; aperture circular, located at the end of the short neck.

Dimensions of holotype: length, including neck, 0.55 mm; maximum diameter, 0.49 mm.

Holotype, no. 46004; paratypes, no. 46005.

Remarks.—This species resembles *L. sphaerica* Moreman in shape and surface texture, but differs in regard to its much shorter, tapering neck. Uncommon in the samples.

Genus THURAMMINA H. B. Brady, 1879
THURAMMINA UNITUBULA Grubbs, n. sp.
Plate 61, figure 7

Test free, flask-shaped, slightly compressed; wall thin, composed of medium sand grains, well cemented; surface rough; aperture circular, located at the end of a single prominent tube.

Dimensions of holotype (no. 46006): length, including tube, 0.43 mm, maximum diameter of body chamber, 0.37 mm.

Remarks.—This species is represented by a single individual. It differs from others in that it has a single apertural tube.

THURAMMINA CYLINDRICA Grubbs, n. sp.
Plate 61, figure 13

Test free, cylindrical; wall thin, composed of fine sand grains, well cemented; surface smooth; apertures at the end of small nipplelike projections, irregularly spaced, more numerous near the margins.

Dimensions of holotype: length, 0.39 mm; diameter, 0.31 mm.

Holotype, no. 46007; paratypes, no. 46008.

Remarks.—This species is distinguished by its cylindrical shape and the concentration of the apertures near the ends of the cylinder. Rare in all samples.

THURAMMINA GLOBULA Grubbs, n. sp.
Plate 61, figures 9, 10

Test free, biscuit-shaped, subcircular in outline, flattened below; wall thin, composed of fine sand grains, well cemented; surface smooth; apertures at the end of short nipplelike projections, seven or eight in number, subsymmetrically arranged around the periphery of the test.

Dimensions of holotype (no. 46009): greatest diameter, 0.68 mm; short diameter, 0.5 mm.

Remarks.—This species resembles *T. subsphaerica* Moreman in outline but differs in its much shorter apertural tubes. Rare.

Family PLACOPSILINIDAE
Genus PLACOPSILINA d'Orbigny, 1850
PLACOPSILINA? LINEATA Grubbs, n. sp.
Plate 61, figures 11, 12

Test attached, of several chambers connected in a linear series; chambers pyriform in outline, attached by flattened lower surface, sharply convex above; wall thin, hyaline; surface smooth; one aperture at the broader end of each chamber, circular, near the center of a subtriangular face which is perpendicular to the plane of attachment; connections between chambers constricted, originating near the base of chamber, below the aperture.

Dimensions of holotype: length of individual chamber, 0.55 mm; greatest width, 0.37 mm; height, 0.18 mm.

Holotype, no. 46010; paratypes, no. 46011.

Remarks.—This rather common form is questionably placed in this genus since sufficient diagnostic material was not available to establish its true relationships. It differs from described species in that apertures are present on each chamber; the outline is similar to *P. rostrata* Quenstedt. The species probably belongs to a new genus.

Phylum COELENTERATA
Class HYDROZOA
Family MONOGRAPTIDAE
Genus MONOGRAPTUS Geinitz, 1852
MONOGRAPTUS? CHICAGOENSIS Grubbs, n. sp.
Plate 61, figure 20

Stipe slender, simple, linear, generally slightly curved; dorsal margin undulating, without a rigid virgula. Polyps subpyriform, slightly truncated distally, nearly paralleling the axis of growth, the ventral margin forming an angle of about 10 degrees with the axis. The polyps originate from one side of a common subcylindrical, coe-

nosarcal canal which is constricted at the points of addition of the new individuals; polyps added uniformly, with no overlap, a new one arising at the point where the plane of the aperture of the preceding polyp intersects the common canal. Apertures slightly elliptical, occupying most of the somewhat flattened face of the anterior margin, direction of aperture elongation at a right angle to the axis of growth, the plane containing the aperture nearly perpendicular to the axis. Surface apparently smooth.

Dimensions of holotype: length of stipe, 1.7 mm; length of individual polyp, 0.49 mm; diameter at aperture, 0.12 mm.

Holotype, no. 46012; paratypes, no. 46013.

Remarks.—This species is represented by a few individual stipes and a number of fragments. All have been referred doubtfully to this genus because the material is not sufficient to determine positively its true generic relationships. The lack of a rigid virgula is a discordant character in these forms, which otherwise seem to show strong graptolite affinities.

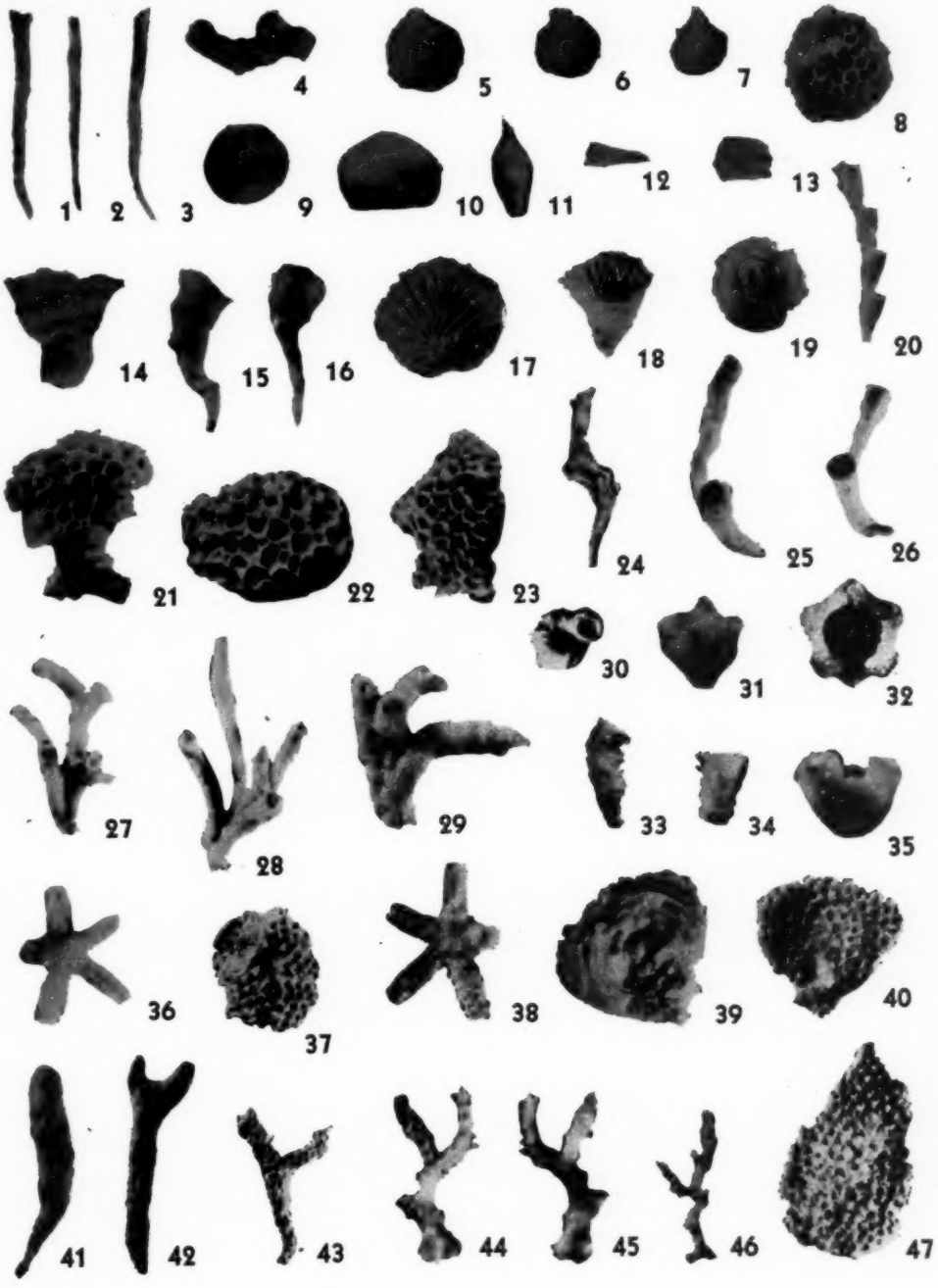
Class ANTHOZOA
Family CYATHAXONIDAE
Genus ASTHENOPHYLLUM Grubbs, n. gen.

Simple turbinate or trochoid coralla of which the calyces occupy about two-thirds the height of the individuals; septa moderately strong, radially disposed, extending uninterrupted to the bottom of the calyces where they reach the center and twist slightly into a pseudocolumella. Septal insertion according to the *Zaphrentis* plan—six protosepta, usually 16 metasepta, finally a minor series inserted in the intervening spaces and remaining rudimentary. Tabulae and dissepiments are lacking in the mature forms; cardinal septum neither in a fossula nor aborted; epitheca marked with rather strong rugae.

Genotype, *Asthenophyllum orthoseptatum* Grubbs, n. sp.

EXPLANATION OF PLATE 61

FIGS. *1–3—Arenosiphon gigantea* Grubbs, n. gen. and sp., ×3. *1, 3,* Paratypes; *2,* holotype (p. 544)
4—Sorosphaera irregularis Grubbs, n. sp. Holotype, ×18. (p. 544)
5, 6—Lagenammina cornuta Grubbs, n. sp., ×20. *5,* Paratype; *6,* holotype. (p. 544)
7—Thurammina unitubula Grubbs, n. sp. Holotype, ×20. (p. 545)
9, 10—Thurammina globula Grubbs, n. sp. *9,* Upper surface of holotype, ×18; *10,* lateral view of holotype, ×20. (p. 545)
11, 12—Placopsilina? lineata Grubbs, n. sp., ×20. *11,* Dorsal view of holotype; *12,* lateral view of paratype. (p. 545)
13—Thurammina cylindrica Grubbs, n. sp. Holotype, ×20. (p. 545)
14–18—Asthenophyllum orthoseptatum Grubbs, n. gen. and sp. *14–16,* Lateral view of paratypes, ×2½; *17,* calicular view of holotype, ×2; *18,* lateral view of holotype, ×1½. (p. 547)
8, 19—Favosites radiculatus Grubbs, n. sp., ×8. *8,* upper surface of paratype; *19,* basal view of holotype. (p. 548)
20—Monograptus? chicagoensis Grubbs, n. sp., ×15. Lateral view of holotype. (p. 545)
21, 22—Favosites michelinoides Grubbs, n. sp., ×3. *21,* Lateral view of holotype; *22,* upper surface of holotype. (p. 548)
23—Favosites variporous Grubbs, n. sp., ×2½. Upper surface of holotype. (p. 548)
24–26—Auloporella typa Grubbs, n. gen. and sp., ×2½. *24,* Sectional view of paratype; *25,* holotype; *26,* paratype. (p. 549)
27–29—Aulozoa constricta Grubbs, n. gen. and sp. *27,* Paratype, ×3½; *28,* holotype, ×3 ; *29,* paratype, ×6. (p. 549)
30—Spirorbis carinacinctus Grubbs, n. sp., ×12. Dorsal view of holotype. (p. 550)
31, 32, 35—Cyathocrinus? nanus Grubbs, n. sp., ×18. *31,* Lateral view of holotype; *32,* oral view of paratype; *35,* lateral view of paratype. (p. 550)
33, 34—Cornulites perspinosus Grubbs, n. sp., ×8. *33,* Dorsal view of holotype; *34,* dorsal view of paratype. (p. 550)
6, 38—Proastrum rectibrachium Grubbs, n. gen. and sp. *36,* Dorsal view of holotype, ×10; *38,* ventral view of holotype, ×11. (p. 551)
37—Ceramoporella racinensis Grubbs, n. sp., ×3. Upper surface of holotype. (p. 551)
39, 40, 47—Pholidopora concentrica Grubbs, n. gen. and sp., ×4. *39,* Basal view of paratype; *40,* upper surface of paratype; *47,* upper surface of holotype. (p. 552)
41–43—Lioclemella clava Grubbs, n. sp., ×1½. *41,* Lateral view of holotype; *42, 43,* lateral view of paratypes. (p. 552)
44–46—Pseudohornera? varipora Grubbs, n. sp., ×7. *44,* Obverse surface of holotype; *45,* reverse surface of holotype; *46,* obverse surface of paratype. (p. 553)



Grubbs, Niagaran fauna

UNIV. OF MICH.

Remarks.—This genus is based on numerous individuals of variable shapes, which have identical septal characteristics and lack tabulae, dissepiments, and fossulae. The deep calyces and the absence of cardinal fossulae, together with the attributes mentioned, separate this genus from previously described forms. The genus is placed with some question in the family *Cyathaxonidae* because the classification of the rugose corals has not yet been satisfactorily developed.

ASTHENOPHYLLUM ORTHOSEPTATUM
Grubbs, n. sp.
Plate 61, figures 14–18

Coralla simple, varying in outward form, generally slightly curved-trochoid at maturity; in the neanic stages increasing the diameter slowly, then flaring rapidly in an erectly turbinate fashion, the apex commonly truncated, otherwise remaining sharply acuminate. Calyx deep, constituting as much as two-thirds of the lumen; calicular opening subcircular to ovoid in outline. Septa unornamented, moderately strong, blade-like, radially disposed, slightly expanded at the peripheral edge but otherwise nearly plane; distally the septa are more or less confined to the calicular walls or extend axially for only a slight distance; vertically they extend uninterrupted to the bottom of the calyx, where they reach the center and twist slightly to form a pseudocolumella, which structure generally confines a vertical axial opening or fenestrule formed by the septa twisting around the axis.

The septal insertion follows the *Zaphrentis* plan, i.e., after the protosepta, metasepta are inserted at four points simultaneously, immediately on each side of the cardinal septum and on the counter side of each alar septum. In the primary stage the cardinal and counter septa are conjoined to form an axial septum and with the alar and counterlateral septa produce six protosepta (figure 1a). The addition of the first four metasepta in their proper positions forms 10 major septa (figure 1b). Additional metasepta are inserted in groups of four to produce neanic stages of 14 (figure 1c), 18 (figure 1d), and finally 22 (figure 1e) major septa.[2] When the number of major septa reaches 22 (occasionally 20), minor septa are added simultaneously in a cycle, in the intervening loculi, to make a total of 44, the maximum septal number observed. The minor septa remain as rudiments, usually as vertical rows of spines.

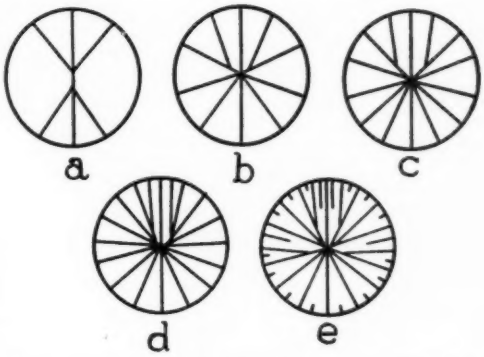


FIG. 1.—Septal development (diagrammatic) in *Asthenophyllum orthoseptatum.*

Tabulae and dissepiments lacking in mature forms, but horizontal, complete tabulae occur sporadically in the proximal portion of the lumen in some neanic coralla. Fossulae altogether lacking; cardinal septum never aborted nor reduced. Epitheca characterized by strong rugae, which do not affect the endodermal wall, and occasional marks of rejuvenescence; longitudinal striae or grooves not observed.

Dimensions of holotype: length of corallum, 7.5 mm; diameter at distal end, 7.0 mm.

Holotype, Walker Museum, no. 46014; paratypes, no. 46015.

Remarks.—The size and septal characters, together with the lack of fossulae, make this species distinctly different from other rugose corals.

[2] It has been noted that although the septa are essentially inserted in groups of four, there is a tendency for one pair to slightly precede the other. The pair on the counter side of the alar septa seem to develop momentarily before the contemporaries adjacent to the cardinal septum. This, in the neanic stages, produces individuals which show 12, 16, and 20 septa that extend entirely to the bottom of the calyx and reach the center.

Family FAVOSITIDAE
Genus FAVOSITES Lamarck, 1812
FAVOSITES RADICULATUS Grubbs, n. sp.
Plate 61, figures 8, 19

Corallum small, composite, hemispherical, attached by a short, subcentral peduncle; lower surface convex, covered with a concentrically striated epitheca; upper surface flat or gently convex; corallites prismatic, pentagonal or hexagonal, confined to the upper face. The young corallites are added around the periphery to produce an area with individuals of smaller diameter than the more mature central ones, those near the margins radiating at a considerable angle from the principal axis of growth. Walls in contact throughout, of medium thickness, expanded slightly at the junctions with those adjacent, often with a slight surficial node rising from the common points of junction. Septa rudimentary, about 12 in number, represented by short sporadic spines in vertical rows; mural pores large, apparently in a single irregular row on each prism face; tabulae obsolete, or consisting of a few horizontal striae on wall surfaces.

Dimensions of holotype: greatest diameter of corallum, 2.4 mm, height including peduncle, 1.5 mm; diameter of average corallite, 0.3 mm.

Holotype, no. 46016; paratypes, no. 46017.

Remarks.—This coral may possibly represent an ontogenic stage of some other form; nevertheless, it is distinctive in its pedunculate attachment and the character of the tabulae. The large number of recognizable young corallites and the relatively larger number of mature ones further suggest that the species is valid.

FAVOSITES MICHELINOIDES Grubbs, n. sp.
Plate 61, figures 21, 22

Corallum small, composite, originating as a single tube, multiplying to form several tubes, and finally expanding rapidly into a globular cluster of corallites. Corallites commonly added as small clusters before the expansion of the main body of the corallum. The original tubular character is retained in part by many mature corallites, but others assume a prismatic section due to crowding. Walls thin, in contact throughout, very slightly thickened at junctions with those adjacent; septa rudimentary, usually 12 or less in number, consisting of vertical rows of short spines; mural pores large, restricted to a single one to two adjacent corallites, a prominent raised margin encircling the pores; tabulae common but not abundant, usually with the upper surfact convex but occasionally flat.

Dimensions of holotype: height of corallum, 7.0 mm; greatest diameter, 5.0 mm; diameter of average corallite, 0.7 mm; average of several specimens: height, 8.0 mm; diameter, 5.0 mm.

Holotype, no. 46018; paratypes, no. 46019.

Remarks.—As suggested by the trivial name this form has the outward appearance of several species of *Michelinia;* however, the porous nature of the walls places it in the genus *Favosites.* The tubular character of the corallites, the convex tabulae, and the single communicating pore for each of the contacting corallites are distinctive features of the species.

FAVOSITES VARIPOROUS Grubbs, n. sp.
Plate 61, figure 23

Corallum composite, bushy, attached; corallites prismatic, usually pentagonal or hexagonal, but varying from three to eight sides, increasing in diameter with growth. Walls moderately thick, in contact throughout, more massive at junctions with those adjacent; septa common, represented by from 12 to 16 vertical rows of rather strong, short spines; mural pores large, arranged in usually a single irregular row on each prism face but exceptionally occurring in two alternate rows, pores with a slightly expanded border. Tabulae horizontal, irregularly spaced, not numerous.

Dimensions of holotype: height of corallum, 3.5 mm; diameter, 9.0 mm; diameter of average corallite, 1.0 mm.

Holotype, no. 46020; paratypes, no. 46021.

Remarks.—This species differs from the common forms of *Favosites* in the arrangement of the mural pores and in the paucity of tabulae.

Family AULOPORIDAE

Genus AULOPORELLA Grubbs, n. gen.

Aulopora-like coralla with secondary inner chambers which produce a double wall; young corallites retaining communication with parent chambers; tabulae and septa apparently lacking.

Genotype, *Auloporella typa* Grubbs, n. sp.

Remarks.—The forms of this genus resemble *Aulopora* Goldfuss, emend. Fenton and Fenton, 1937, in outward appearance. A secondary inner chamber has been developed in the anterior portion of the individual corallites and forms a double-wall effect which extends into the young tubes as they are added.

AULOPORELLA TYPA Grubbs, n. sp.
Plate 61, figures 24–26

Corallites trumpet-shaped, attached by most of the lower surface, expanding toward the anterior; anterior directed vertically, the vertical portion often comprising as much as one-half the length of the individual; apertures circular, sometimes slightly constricted; walls thick; surface smooth or faintly wrinkled. New tubes are added near the base of the parent cup, often two or three to an individual, directed forward or at various angles, retaining communication with the parent. A secondary saclike chamber is produced in the anterior portion of the corallites and forms an inner wall, which is not in contact throughout with the outer, but with an intermediate open space; walls coalescing near the aperture. The double-wall character passes from the parent cup into the young as they are added. Septa rarely present; tabulae or diaphragms apparently lacking.

Dimensions of holotype: length of individual corallite, 6.0 mm, length of upturned portion, 2.0 mm; greatest diameter, 1.5 mm.

Holotype, no. 46022; paratypes, no. 46023.

Remarks.—Many species of *Auloporidae* have been inadequately described, especially in relation to the internal features, hence there is question as to the affinities of this species. Its external features are similar to several Silurian forms that have been assigned to the genus *Aulopora*, but the distinctive internal character seems to warrant a new generic designation. It is likely that some previously described species belong to this genus. The forms are common in the nodules.

Genus AULOZOA Grubbs, n. gen.

Corallum attached, consisting of tortuous constricted tubes that maintain about the same diameter throughout; from one to five or six new tubes may be added within a short space by gemmation at any position around the parent, all of the tubes having the same general direction of growth, with a tendency to be directed slightly upward near the apertural end. Young tubes in communication with the parent by means of a small subcircular opening at the point of origin. Apertures circular; tabulae apparently lacking; septa rudimentary.

Genotype, *Aulozoa constricta* Grubbs, n. sp.

Remarks.—This genus differs from other auloporid types in that it is attached by a limited portion of the lower surface and the tubes are constricted at numerous places and do not increase their diameter toward the aperture. The young tubes retain communication in an extraordinary manner.

AULOZOA CONSTRICTA Grubbs, n. sp.
Plate 61, figures 27–29

Corallum attached by a limited portion of the lower surface, consisting of small subcylindrical, tortuous, scolecoid tubes, constricted in many places, the tubes retaining nearly the same diameter throughout their length. The parent tube produces new individuals irregularly, adding from one to five or six new individuals in a short space, the tubes arising from any or several positions on the parent and forming in some cases a somewhat crowded cluster of individuals. The tubes diverge at different angles, but all have a general anterior direction of growth, and tend to be directed slightly upward near the apertural ends. Young tubes retain communication with the parent by means of a small subcircular wall opening at the point of origin; where crowded the tubes may be polygonal for a short distance but always retain their individuality. Apertures circular; tabulae ap-

parently lacking; septa consisting of a few rows of short spines.

Dimensions of holotype: length over all, 9.6 mm; diameter of average tube, 0.85 mm.

Holotype, no. 46024; paratypes, no. 46025.

Remarks.—This species is represented abundantly in the material. The differences between the genus and similar forms of the same family have been pointed out under the generic description; the same criteria apply to the species. It resembles in outward appearance the fresh water bryozoan genus *Plumatella*, and since the status of the auloporid corals is not clearly defined, this species may possibly belong to some other group.

Phylum ANNELIDA
Genus SPIRORBIS Lamarck, 1801
SPIRORBIS CARINACINCTUS Grubbs, n. sp.
Plate 61, figure 30

Shell a small spiraled tube of about two and one-half volutions, attached by one volution then ascending toward the apertural end. Aperture circular, with a slightly flared lip; surface ornamented with strong, sharp annulations that rise above the surface a distance equal to about one-half the diameter of the tube proper, eight or nine annulations to one volution. Longitudinal striae occupy the spaces between the annulations.

Dimensions of holotype (no. 46026): diameter of shell, 0.87 mm, diameter of aperture, 0.36 mm.

Remarks.—This species resembles *S. annulatus* Hall from the Salem limestone in general shape and appearance. It differs in that it is smaller, and the annular carinae are stronger, sharper, and more widely spaced.

Genus CORNULITES Schlotheim, 1820
CORNULITES PERSPINOSUS
Grubbs, n. sp.
Plate 61, figures 33, 34

Shell a small tubular cone, straight or slightly curved, flattened on lower surface for attachment. The shell in cross-section is subcircular, diameter increasing somewhat toward aperture; aperture circular, in some cases with a slightly flared lip. Surface with numerous rather strong spines, irregularly spaced, directed anteriorly; annulations especially prominent on the interior of the shell.

Dimensions of holotype: length, 2.0 mm, diameter, 0.63 mm.

Holotype, no. 46027; paratypes, no. 46028.

Remarks.—The species has been placed in this genus with a degree of uncertainty. The attached mode of growth and the general shell shape are suggestive of *Cornulites*. The unusual spinosity is a distinctive feature.

Phylum ECHINODERMA
Class CRINOIDEA
Genus CYATHOCRINUS Miller, 1821
CYATHOCRINUS? NANUS Grubbs, n. sp.
Plate 61, figures 31, 32, 35

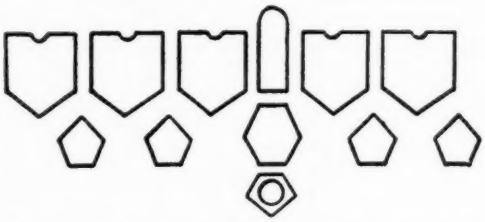


FIG. 2.—Plate arrangement (diagrammatic) of *Cyathocrinus? nanus*.

Calyx minute, cup-shaped, bilaterally symmetrical, arms free above the radials; plate arrangement dicyclic, three cycles of plates united by close suture. Proximal cycle, which apparently represents small infrabasals, fused into a single dorsally convex, pentagonal plate. Basals five, four of them equal, pentagonal, slightly convex below, the fifth, or posterior basal, hexagonal, extended slightly above the other basals. Radials five, larger than the basals, pentagonal, subequal, the two posterior plates slightly narrower; radial plates in contact except posteriorly where the anal plate is inserted in the cycle. The radials are evenly truncated above, semicircular arm facets occupying probably one-half of the upper margins, the facets directed outward. Anal plate in the radial cycle, resting on the truncated upper margin of the posterior basal plate, extending ventrally above the radials. Column circular; oral plates and arms not observed. Surface smooth.

Dimensions of holotype: height of dorsal cup, 0.62 mm; diameter at upper margin, 0.7 mm.

Holotype, no. 46029; paratypes, no. 46030.

Remarks.—The generic designation of this species is questionable since the tegmen and arms are not preserved. The arm facets are larger than is typical of the genus; the anal plate is somewhat more extended than in other species.

INCERTAE SEDIS

Genus PROASTRUM Grubbs, n. gen.

Shell pentagonally symmetrical, composed of a central body and five rigid arms in a plane, arms not an integral part of body cavity. Ventrally the arms are fitted with an alternating series of tuberculate plates. The body cavity bears an elevated centrodorsal plate with a median perforation.

Genotype, *Proastrum rectibrachium* Grubbs, n. sp.

Remarks.—This genus is erected to accommodate a single peculiar specimen whose symmetry indicates a relationship to the echinoderm group. As the plate arrangement is obscure it is impossible to classify the form properly; some features suggest relation to the asteroid group.

PROASTRUM RECTIBRACHIUM

Grubbs, n. sp.

Plate 61, figures 36, 38

Shell small, pentagonally symmetrical, consisting of a slightly inflated central body, subcircular in outline, and five rigid arms which are not a part of the body cavity. The arms are in a single plane, about twice as long as the diameter of the central body, and about one-half as wide as same; longitudinally the arm margins are parallel except distally where the arms taper and are terminally rounded. The dorsal side of the arms is angularly convex in cross-section; ventrally the arm proper is deeply concave, but fitted with a covering of plates, two rows that interfinger and alternate in position. The plates bear prominent subconical protuberances along the outer margins, one to each plate, or a total of about eight in each row. A subcircular centrodorsal plate is considerably elevated above the body cavity; the plate bears a small circular central perforation.

Dimensions: Diameter of body cavity, 0.6 mm; length of arms, 0.9 mm; width, 0.36 mm.

Holotype, no. 46031.

Remarks.—This species is based on an individual that is markedly different from described forms. The symmetry is strongly suggestive of the stelleroid groups, and if the specimen belongs to one of these, the perforated dorsal plate should represent a madreporic or an anal plate, and the ventral arm tubercules might possibly be homologues of ampullae. If, on the other hand, the form belongs to the pelmatozoans, the dorsal plate should represent a facet that formerly marked the connection of a columnal. It is also possible that this is a rare type of bryozoan, similar to those of the genus *Evactinopora*.

Phylum BRYOZOA

Family CERAMOPORIDAE

Genus CERAMOPOPRELLA Ulrich, 1882

CERAMOPORELLA RACINENSIS Grubbs, n. sp.

Plate 61, figure 37

Zoarium encrusting, consisting of thin-walled, close-spaced, alternating and imbricating zoœcia radiating more or less uniformly from a common noncelluliferous mid-area. Zoœcia tubular, oblique, the greater part covered by subangular hoods, extensions of the lunaria, which commonly show a slight ridge at the apex. Apertures subangular, obliquely directed; maculae and diaphragms lacking. Mesopores large, occupying most of the interzoœcial space, a single row separating adjacent zoœcia, two or three pores to a distance equalling the length of a zoœcial hood.

Dimensions of holotype (no. 46032): diameter, 5.0 mm; diameter of zoœcia 0.35 mm. three zoœcia to a longitudinal distance of 2 mm.

Remarks.—This species resembles *C. interporosa* Ulrich, from the Ordovician. It differs in that the zoœcia are more regularly disposed and the hoods are stronger, more angular, and have an apicle ridge. It differs from the Silurian forms *C. orbiculata* (Ringenberg) and *C. irregularis* Bassler in that maculae have not been observed, but all

growth is a radiation from a central area. Rare in the samples.

Genus PHOLIDOPORA Grubbs, n. gen.

Zoarium thin, encrusting in the early stages, at maturity developing a concentrically wrinkled epithecal membrane over the lower surface and retaining a subcentral cicatrix of attachment. Zoœcia tubular, oblique, irregularly alternating and imbricating, radiating from a central area; lunaria extended into strong hoods; zoœcial chambers with a few partial diaphragms or hemiphragms, noncommunicating. Maculae and mesopores lacking.

Genotype, *Pholidopora concentrica* Grubbs, n. sp.

Remarks.—This genus has several distinctive features which separate it from other genera of the encrusting cyclostomous bryozoans. The epithecal membrane seems to be distinctive in this genus, and the lack of mesopores separates it from several genera. The zoœcia are separated by rather thick intervening spaces. A feature of the zoœcial chambers is the development of partial diaphragms, so-called hemiphragms, which extend partially across the chambers but do not divide them into compartments.

PHOLIDOPORA CONCENTRICA Grubbs, n. sp.
Plate 61, figures 39, 40, 47

Zoarium thin, encrusting in the early stages and at maturity developing a convex concentrically wrinkled and striated epithecal membrane over the lower surface. The membrane retains a central cicatrix of attachment. Zoœcia short, tubular, radiating irregularly in an alternating and imbricating manner, separated by wide intervening spaces, obliquely directed, more so toward the periphery than near the mid-area; lunaria projecting into the zoœcia posteriorly, extended anteriorly into highly arched hoods, subangular in section, the hood apex acutely rounded, hoods curving slightly near the point of origin then straightening toward the aperture. Zoœcial chambers with one or two partial diaphragms or hemiphragms originating from the side of the walls and reaching nearly to the midline, terminating with a straight margin, which is perpendicular to the axis of growth of the individuals. In some cases two hemiphragms oppose one another but more commonly their position is alternate. The straight margins produce the appearance of an open rectangular notch in anterior view. Interzoœcial areas without mesopores; surface without maculae; apertures elliptical.

Dimensions of holotype: maximum diameter of zoarium, 6.8 mm; diameter of zoœcia, 0.25 mm; zoœcia spaced 5 to 3 mm longitudinally.

Holotype, no. 46033; paratypes, no. 46034.

Remarks.—The distinctive characteristics of this species have been listed under the generic discussion. The broad interzoœcial spaces, the lack of mesopores, the hemiphragms, and the concentric lower membrane distinguish this species from other ceramoporids.

Family BATOSTOMELLIDAE
Genus LIOCLEMELLA Foerste, 1895
LIOCLEMELLA CLAVA Grubbs, n. sp.
Plate 61, figures 41–43

Zoaria consisting of tapering, clublike stems, occasionally branching, the proximal end pointed for articulation. Zoaria subcircular in cross-section, the greatest diameter near the rounded distal extremity; centers of the individual zoaria hollow, commonly assuming a spiral character. Zoœcia subcircular, more or less regularly spaced, six in a distance of 4 mm, oblique at first, then directed toward the surface. In most individuals a few large pores or holes occur at or near the distal end, probably irregularities of preservation or replacement.

Dimensions of holotype: length of zoarium, 20.0 mm; greatest diameter, 4.0 mm.

Holotype, no. 46035; paratypes, no. 46036.

Remarks.—These forms have been replaced by silica in such a manner that the detailed structure of the zoœcia and walls has been obliterated, hence the species is erected principally on the basis of shape. It differs from *L. maccombi* Bassler in that the greatest diameter is near the distal end, and also the forms occasionally branch. It differs from *L. ohioensis* (Foerste) in that it is circular rather than elliptical in section, and the diameter is greatest near the distal end. Abundant.

Family PHYLLOPORINIDAE
Genus PSEUDOHORNERA Roemer, 1876
PSEUDOHORNERA? VARIPORA Grubbs, n. sp.
Plate 61, figures 44–46

Zoarium a frond, branching irregularly in one plane, growing from an expanded base; branches subcircular to elliptical in cross-section. Zoœcia deep, tubular, nearly direct, irregularly disposed over the convex obverse face, crowded in some portions. The apertural openings are subcircular, with a sharp peripheral rim raised slightly above the surface of the branches. Reverse side of branches convex, noncelluliferous, marked with three or four granulose, longitudinal striae.

Dimensions of holotype: length of zoarium, 3.5 mm, diameter of average branch 0.3 mm; diameter of apertures, 0.24 mm.

Holotype, no. 46037; paratypes, no. 46038.

Remarks.—This species is referred to the genus with some question, for irregularly spaced zoœcia apparently have not been observed before in *Pseudohornera*. The forms correspond to the generic description in the frondescent character and in that only one side bears zoœcia, the other being marked with striae. The species differs from *P. niagarensis* (Hall) and *P. diffusa* (Hall) in that it branches more irregularly, does not have an angular obverse face, and in the character of the zoœcia mentioned above. Uncommon in the samples.

Family FENESTRELLINIDAE
Genus FENESTRELLINA d'Orbigny, 1849
FENESTRELLINA PERCARINATA
Grubbs, n. sp.
Plate 62, figures 1, 2

Branches essentially straight, depth more than twice as great as width due to a strong obverse keel; fenestrules rectangular or elongate-ovate as the result of the distal expansions of the dissepiments, length of fenestrules about twice the width. The dissepiments are rounded, considerably expanded at the junctions with the branches, width about one-half that of the branches. Obverse side of branches with a strong, sharp keel which accounts for more than one-half the depth of the branches. The zoœcia are arranged in two alternating rows, a row on each side of the keel; apertures subcircular, three or four to a fenestrule, spaced about two-thirds the width of an aperture apart. Apertures situated on an oblique face produced by the keel at its junction with the branch proper, the apertural plane forming an angle of about 15° with the vertical. Reverse side of branches angularly convex, with the suggestion of a slight keel, or in some cases more nearly rounded. Both faces of branches, keel included, ornamented with minute tubercules, arranged in several rows, producing the appearance of striae on casual observation.

Dimensions of holotype: width of branch, 0.37 mm; depth including keel, 1.5 mm; length of fenestrule, 0.93 mm; width, 0.44 mm; diameter of aperture, 0.12 mm; apertures spaced 10 to 2.5 mm.

Holotype, no. 46039; paratypes, no. 46040.

Remarks.—Fragments of this species are common in the nodules, but zoaria of considerable size are lacking. The forms resemble the many described species of this genus; they are characterized by the extremely high keel, the oblique apertural plane, and the minutely spinose surfaces. In rare cases minute spines arise outside of the apertures and a short distance above are joined to form a ring, with about six short spines, which project inward from the inner margin of the ring.

Family ARTHROSTYLIDAE
Genus ARTHROSTYLUS Ulrich, 1888
ARTHROSTYLUS PENTAGONUS Grubbs, n. sp.
Plate 62, figure 4

Zoaria slender, straight, subpentagonal in cross-section; zoœcial openings in a single row on each of four sides, the fifth side narrower and without zoœcia, and marked with four longitudinal striae. Zoœcial apertures large, elongate-ovate, nearly direct, commonly with a peristomal ridge. An angular ridge marks the intersection of the faces bearing the zoœcia.

Dimensions of holotype: length of zoarium, 5.1 mm, diameter, 0.5 mm; zoœcia, 0.5 mm in length, spaced 9 to 5 mm.

Holotype, no. 46041; paratypes, no. 46042.

Remarks.—This species differs from *A.*

conjunctus Ulrich in that it has four rows of apertures rather than three, and the apertures are more elongate. It differs from *A. obliquus* Ulrich in its four zoœcial rows and in that the apertures are more direct with respect to the surface.

Family RHINIDICTYONIDAE
Genus RHINIDICTYA Ulrich, 1882
RHINIDICTYA AEQUIELLIPTICA Grubbs, n. sp.
Plate 62, figures 5–7

Zoarium bifoliate, attached by an expanded base, subcylindrical in the lower portion then expanding into paddle-like, elliptical bodies, in some cases tortuous, bifurcating at irregular intervals. The individual branches are acutely elliptical in cross-section, width commonly as much as five times the depth, sides subparallel, sharp, with a very narrow noncelluliferous margin; terminally the branches are convex in outline. Zoœcia irregularly arranged around the basal portion, filled with sclerenchyma; above the base the zoœcia are regularly disposed on both faces of the elliptical portions of the branches, in from three to six, most commonly five alternating rows; apertures of the marginal rows somewhat larger than those of the inner rows, directed slightly obliquely outward. Zocœia directed slightly toward the anterior, separated by moderately thick walls, apertures elongate, regularly elliptical, length about twice the width. The upper edges of the walls separating the zoœcia are marked with rows of minute spines, with the appearance of striae, especially prominent on the lower portion of the zoarium. From one to three faint outwardly divergent striae commonly are visible in the bottom of the zoœcia; commonly they are better shown near the margins.

Dimensions of holotype: width of branch 1.9 mm; depth 0.9 mm; length of average aperture, 0.5 mm; width, 0.25 mm; zoœcia spaced longitudinally eight to a distance of 5 mm.

Holotype, no. 46043; paratypes, no. 46044.

Remarks.—This species is abundantly represented in the material. Its mode of development and elliptical character of the branches resemble very closely *R. exigua* Ulrich from the Ordovician, but it differs in that the apertures are more uniformly elliptical, the zoœcia are directed toward the distal extremities, and the bottoms of the zoœcia are marked with striae.

Phylum BRACHIOPODA
Order NEOTREMATA
Family CRANIIDAE
Genus PHOLIDOPS Hall, 1859
PHOLIDOPS PARVUS Grubbs, n. sp.
Plate 62, figure 3

Shell small, oblong-ovate in outline, biconvex, greatest width near the midline. Ventral valve eccentrically convex with a flattened indistinct beak situated in the posterior half of the valve; slope from beak to the posterior steeper than slope to the anterior. Dorsal valve less convex than the ventral. Surface commonly marked with five or six imbricating growth lines. The interior of the ventral valve shows a subcircular thickening with a bilobate aspect, suggestive of two sets of adductor muscles. Dorsal interior with an indistinct complement.

Dimensions of holotype: length, 2.5 mm; width, 2.2 mm.

Holotype, no. 46045; paratypes, no. 46046.

Remarks.—This rather common form is similar in general shape and aspect to several species of the genus. It differs from the Silurian *P. ovalis* Hall in that it is more elongate and shows fewer growth lines. It also shows fewer growth lines than Devonian species and usually its ventral valve is not as deep and its beak not as prominent as in other species.

Order PROTREMATA
Family SPHENORTHIDAE Grubbs, n. fam.

Primitive compressed-elongate Orthacea with short, curved hinge lines; deltidia, chilidia, cardinal processes, and spondylia wanting.

Genus SPHENORTHIS Grubbs, n. gen.

Small, compressed, elongate-triangular shells, laterally concavoconvex; hinge line short and strongly curved; delthyrium large, open. Surface multicostate. Ventral hinge simple, short teeth bounding the delthyrium; dorsal cardinalia consisting of brachiophores without supporting plates.

Spondylia, septa, and cardinal processes lacking.

Genotype, *Sphenorthis niagarensis* Grubbs, n. sp.

Remarks.—This genus has several features characteristic of primitive Orthacea, notably the absence of a cardinal process and the lack of dental plates and lamellae. The wide, open delthyrium, the character of the brachiophores, and the position of the ventral teeth are attributes of the group. A new genus and a new family are necessary since the singular form of the species, the curved hinge line, and the internal features do not permit placing it in any established category.

SPHENORTHIS NIAGARENSIS Grubbs, n. sp.
Plate 62, figures 9–11

Shell small, transverse-spatulate, compressed, elongate-triangular in outline, length about twice as great as width, greatest width at or near the anterior extremity. The lateral margins are blunt, nearly straight, and converge toward the posterior; shell in the posterolateral region deep, producing the appearance of a broadly curved, false interarea that is wide at the posterior and diminishes around the lateral margins toward the anterior. The shell is concavoconvex in lateral section; ventral valve broadly arched laterally, nearly flat transversely, with a prominent flattened beak extending for a considerable distance past the posterior margin of the dorsal valve, beak not incurved; ventral interarea apsacline, short, triangular, high, occupied almost entirely by a large open delthyrium. Dorsal interarea extremely low, almost imperceptible, with a slight median notch; beak represented by a slight boss. Surface of both valves with about 11 strong, nonbifurcating transverse ribs radiating from the apex; ribs crossed by numerous slightly flared concentric lirations.

The interior of the ventral valve is fitted with a pair of small teeth, one at each side of the delthyrium; dorsal interior with a pair of subparallel, moderately long, anteriorly pointed brachiophores, which are not supported by plates and unite with the shell at the posterior extreme. Spondylium, septa, and cardinal process lacking.

Dimensions of holotype (no. 46047): length, 4.3 mm; width, 2.5 mm; thickness, 1.2 mm.

Remarks.—This species is based on a single individual, but its extraordinary shape and perfect state of preservation warrant its introduction to the literature. In order to keep the specimen intact only those internal features were described which could be observed through the large open delthyrium. Apparently the form belongs to the superfamily Orthacea.

Family ANOMALORTHIDAE
Genus ANOMALORTHIS Ulrich and Cooper, 1936
ANOMALORTHIS CHICAGOENSIS Grubbs, n. sp.
Plate 62, figures 8, 13

Shell small, resembling *Cyrtina*, hemipyramidal, subquadrate in outline, width somewhat greater than length. The hinge line is straight, slightly shorter than the greatest width of the shell. Ventral valve convex-hemipyramidal, interarea triangular, high, slightly concave, with a large open, triangular delthyrium; in young forms a convex deltidium covers the apex of the delthyrium; beak prominent, slightly incurved. The dorsal valve is gently convex, with a slight notch at the posterior margin opposing the ventral delthyrium; beak small. Surface of ventral valve ornamented with commonly 13 rounded plications, the median one slightly larger than the others and forming a small fold at the anterior margin; dorsal exterior with corresponding plications and a slight anterior sulcus. Both valves marked with three or four concentric growth lines.

Ventral interior with a prominent, thickened, sessile spondylium; hinge teeth small, at lateral margins of the delthyrium; dental plates directed ventrally to coalesce with the lateral margins of the spondylium. Dorsal cardinalia orthid in character; brachiophores strong, bounding a small, shallow notothyrial cavity, directed anterolaterally; cardinal process a rather strong rounded median ridge, myophore roughened.

Dimensions of holotype: length, 1.0 mm; width, 1.4 mm; thickness, 0.6 mm; figured ventral valve: length, 2.1 mm; width, 2.5 mm.

Holotype, no. 46048; paratypes, no. 46049.

Remarks.—Individuals of this species are uncommon in the material. They resemble in many respects species described by Ulrich and Cooper, but differ in that the surface ornamentation is in the form of undulant plications rather than multicostellate. The general outline and convexity of the valves also differ from other species.

Family STROPHOMENIDAE
Genus PLECTAMBONITES Pander, 1830
PLECTAMBONITES CONCENTRILIRATUS
Grubbs, n. sp.
Plate 62, figures 12, 15–17

Shell small, semicircular in outline, concavo-convex, width greater than length. The hinge line is straight and is the greatest width of the shell; cardinal extremities extended into wings or acuminate points. Ventral valve more or less evenly convex transversely, concave laterally from the umbo toward the extremities; anterior margin evenly convex. The beak is small, pointed, perforated by a small circular foramen, incurved over an extremely low triangular interarea, which extends the entire width of the shell and bears a small, triangular delthyrium; delthyrium with an arcuate, convex deltidium at the apex. Dorsal valve concave, closely fit to ventral valve, with a minute beak and an interarea of smaller proportions than that of ventral valve. Shell surface smooth except for very fine concentric lirations.

Ventral hinge teeth small, at each side of the delthyrium. The dorsal valve bears short, rather strong, stumplike brachiophores closely spaced to confine pedicle passage, extending slightly posteroventrally and passing into a cardinal process, which occupies part of the delthyrium and is visible from the exterior; myophore roughened. Inner surface of both valves with numerous short, anteriorly directed spines, arranged more or less in alternating rows.

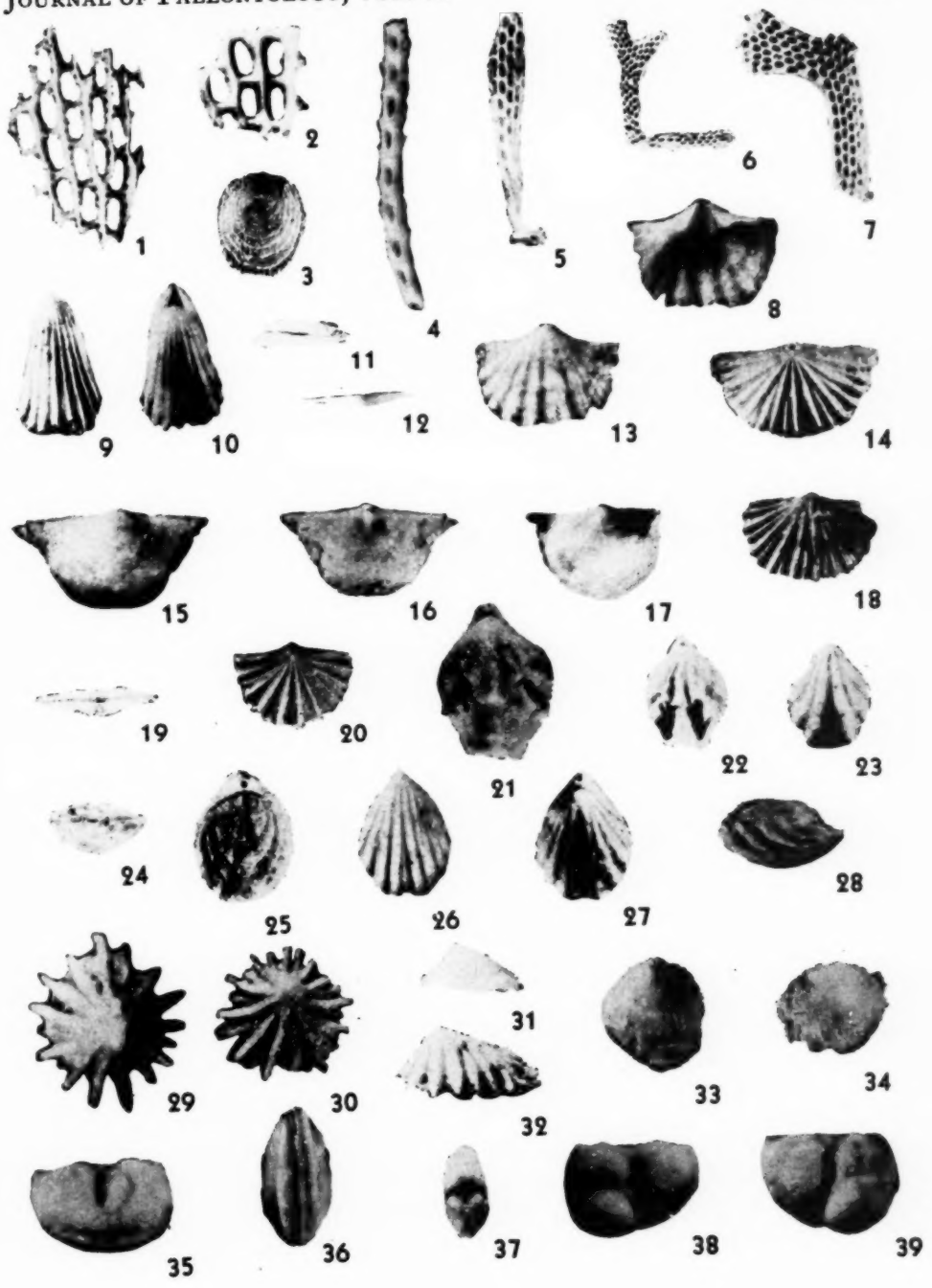
Dimensions: There is considerable range in the size of the individuals of this species. The holotype is 3.0 mm long and 6.0 mm wide. This is average for the group.

Holotype, no. 46050; paratypes, no. 46051.

Remarks.—This species differs from most of the members of the genus in that it is not longitudinally striate, but concentrically marked. The spinose character of the in-

EXPLANATION OF PLATE 62

FIGS. *1, 2—Fenestrellina percarinata* Grubbs, n. sp. *1*, Obverse surface of paratype, ×3; *2*, reverse surface of holotype, ×4. (p. 553)
3—Pholidops parvus Grubbs, n. sp., ×6. Ventral view of paratype. (p. 554)
4—Arthrostylus pentagonus Grubbs, n. sp., ×9. Lateral view of holotype. (p. 553)
5–7—Rhinidictya aequielliptica Grubbs, n. sp. *5*, Holotype, ×4; *6*, paratype, ×2; *7*, paratype, ×3. (p. 554)
9–11—Sphenorthis niagarensis Grubbs, n. gen. and sp. *9*, Ventral view of holotype ×5; *10*, dorsal view of holotype, ×5; *11*, lateral view of holotype, ×3. (p. 555)
8, 13—Anomalorthis chicagoensis Grubbs, n. sp., ×8. *8*, Interior of ventral valve of paratype; *13*, ventral view of paratype. (p. 555)
12, 15–17—Plectambonites concentriliratus Grubbs, n. sp. *12*, Posterior view of holotype, ×3; *15*, ventral view of holotype, ×5; *16*, dorsal view of holotype, ×4; *17*, ventral view of paratype, ×4. (p. 556)
14, 18–20—Schuchertella perconcinna Grubbs, n. sp. *14*, Dorsal view of holotype ×4; *18*, ventral view of paratype, ×4; *19*, posterior view of holotype, ×3; *20*, dorsal view of paratype, ×6. (p. 557)
21–25—Atrypina magnaventra Grubbs, n. sp. *21*, Dorsal view of holotype, ×5; *22–24*, dorsal, ventral and lateral views of paratype, ×3; *25*, dorsal view of paratype, ×3. (p. 557)
26–28—Homoeospira cyclothyra Grubbs, n. sp., ×4½. Ventral, dorsal, and lateral views of holotype. (p. 558)
29, 30, 32—Propatella magnacostata Grubbs, n. gen. and sp. *29*, Upper surface of paratype, ×8; *30*, upper surface of holotype, ×6; *32*, lateral view of holotype, ×6. (p. 558)
31, 33, 34—Punctopatella corallifera Grubbs, n. gen. and sp. *31*, Lateral view of holotype, ×6; *33*, upper surface of holotype, ×7; *34*, upper surface of paratype, ×7. (p. 559)
35–39—Beyrichia gregaria Grubbs, n. sp. *35*, Left valve of holotype, ×7; *36*, ventral view of holotype, ×7; *37*, dorsal view of paratype, ×5; *38*, right valve of paratype, ×7; *39*, left valve of paratype, ×7. (p. 559)



Grubbs, Niagaran fauna

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terior is distinctive, and the species may therefore belong to a new genus.

Genus SCHUCHERTELLA Girty, 1904
SCHUCHERTELLA PERCONCINNA
Grubbs, n. sp.
Plate 62, figures 14, 18–20

Shell small, unequally biconvex to subplanoconvex, semicircular in outline. Shell slightly wider than long, greatest width at or near the straight hinge line; anterior margin rounded. Valves subequal; ventral valve more convex than dorsal and bears a slightly elevated umbo and a rather small incurved beak; apex of beak perforated by a minute circular foramen. Valve surface, from the umbo laterally to the cardinal extremities, flattened or in some individuals slightly concave. Ventral interarea low, slightly concave, triangular, and does not reach the cardinal extremities; delthyrium triangular, slightly broader than high, with an arcuate, convex deltidium covering the apical portion. The dorsal valve is gently convex, approaching flatness in some individuals; beak small, incurved. Surface of both valves with strong, rounded costae, radiating from the umbones. There are commonly 11 primary costae on the dorsal valve and 12 on the ventral valve, intercalated with a variable number of shorter secondary costae. Numerous indistinct, concentric growth lines present a fluted appearance where they cross the costae.

Ventral valve fitted with rather strong teeth at lateral margins of the delthyrium and dental plates which extend toward and finally coalesce with the shell to form curved septa, convex toward the midline. The dorsal valve bears strong anteriorly pointed brachiophores arranged in a broad V, the apex extending past the posterior margin to produce a short cardinal process. Myophore roughened by small tubercules and extending posteriorly slightly past the interarea, so that it is visible on the exterior of the shell. There is an interior reflection of the outer surface markings.

Dimensions: The individuals range in width from 1.0 mm to 7.0 mm. Holotype: length, 3.3 mm; width, 5.5 mm; thickness, 1.2 mm.

Holotype, no. 46052; paratypes, no. 46053.

Remarks.—This species has several features in common with related forms. It differs from *S. subplana* (Conrad) and *S. interstriata* (Hall) in that the hinge line is the greatest width of the shell and the costae are coarser. The costae, although not as numerous, have the appearance of *S. pecten* (Roemer) from Tennessee. The hinge features and cardinalia are similar to *S. subplana* (Conrad).

Order TELOTREMATA
Family ATRYPIDAE
Genus ATRYPINA Hall and Clarke, 1893
ATRYPINA MAGNAVENTRA Grubbs, n. sp.
Plate 62, figures 21–25

Shell small, roughly elongate-pentagonal, length greater than width, greatest width near the median part of shell. The margin is bluntly rounded anteriorly, diverges to the greatest width of the shell, then converges more acutely to the posterior. Hinge line short, strongly curved. Ventral valve deeply convex, with a large, rounded, greatly incurved beak, which extends well past the posterior margin of the dorsal valve and is truncated by a large circular foramen. Delthyrium covered in young individuals with deltidial plates, obscured in mature forms by the incurved beak of ventral valve. Dorsal valve gently convex or nearly flat; beak small, obscured by ventral beak. Surface of the ventral valve with six broadly rounded plications, the two median ones elevated in the form of a shallow fold, which dies out at the umbo; dorsal valve with five plications, the median one in a shallow sulcus, which dies out near the center of the valve; plications non-bifurcating. Usually two or three imbricating growth lines are present; shell rather thick.

The interior of the ventral valve has small laterally striated dental plates, which pass into strong, rounded teeth, recurved toward the posterior. The teeth articulate in sockets of the dorsal valve at the sides of small plates, which are in a subparallel position with respect to the horizontal; the plates approach the mid-line but are separated by a rectangular notch.

Dimensions of holotype: length, 4.7 mm; width, 3.5 mm; thickness, 2.3 mm.

Holotype, no. 46054; paratypes, no. 46055.

Remarks.—This species is similar in many respects to *A. disparilis* (Hall) and *A. intermedia* (Hall), but differs in that it is more elongate, more ventricose, has a more strongly developed ventral beak, and the plications do not bifurcate. Common in the samples.

Family RHYNCHOSPIRINIDAE
Genus HOMOEOSPIRA Hall and Clarke, 1893

HOMOEOSPIRA CYCLOTHYRA Grubbs, n. sp.
Plate 62, figures 26–28

Shell small, oblong-subovate in outline, biconvex, nearly twice as long as wide, the greatest width just anterior to the midpoint of the ventral valve; anterior margin bluntly rounded and slightly indented at the midline. Valves subequally convex; hinge line short and strongly curved. The ventral valve is slightly the more convex and bears a pointed incurved beak, which extends for some distance past the dorsal posterior; delthyrium covered by moderately large, flat or slightly convex deltidial plates, which coalesce and produce a slight median ridge at their junction. A circular foramen is situated at the apex of the plates, under and bounded by but not transgressing, the extreme apex of the beak. Dorsal valve subovate in outline, its beak incurved, obscured by that of ventral valve. Ventral surface commonly with 11 rounded, nonbifurcating costae, radiating from the umbo, two costae slightly elevated in the form of a broad fold, separated by a wide intervening space in the form of a shallow sulcus bearing a very small rib. The dorsal valve has a corresponding number of costae, the two median ones about half as strong as the others and occupying a shallow sulcus, which diverges from the umbo with a slight outward curve; both valves with fine concentric lirations and stronger growth lines.

Ventral interior with short, strong teeth, originating from the lateral margins, curved toward the posterior; articulating outside of the dorsal brachiophores; dorsal valve with subparallel brachiophores extending into the ventral umbonal cavity, supported by plates which are directed laterally and coalesce with the shell; brachiophores separated by a wide, angular notch; median septum rudimentary. Spiralia spinose, consisting of three or four volutions; jugum complete.

Dimensions of holotype: length, 4.0 mm; width, 2.5 mm; thickness, 1.8 mm.

Holotype, no. 46056; paratypes, no. 46057.

Remarks.—This species differs from *H. evax* (Hall) and most other species of the genus in that the foramen is confined to the apex of the deltidial plates. It is also more elongated and its surface markings are distinctive.

Phylum MOLLUSCA
Class GASTROPODA
Family ACMEIDAE
Genus PROPATELLA Grubbs, n. gen.

Moderately low, nonspiraled, cone-shaped patellids with a subcentral apex; surface with strong radiating ribs, elevated above the shell surface and not reflected on the interior; inner surface finely punctate; muscle scars represented by a slight impression on each side of the apex.

Genotype, *Propatella magnacostata* Grubbs, n. sp.

Remarks.—This genus differs from forms generally assigned to *Palaeacmaea* Hall in the punctate inner surface and in that the strong radial ribs are not reflected on the interior of the shell.

PROPATELLA MAGNACOSTATA
Grubbs, n. sp.
Plate 62, figures 29, 30, 32

Shell a small, ribbed cone, subcircular or slightly ovoid in outline. A high, rather prominent, nonspiraled apex is eccentrically located nearer to and incurved toward the posterior, producing a slight posterior concavity in lateral aspect; slope anterior from the apex slightly convex. Surface ornamented with a variable number (commonly 10 or 12) primary, strong, elevated, rounded ribs, intercalated with numerous secondary ribs, the total in some specimens reaching 40. In section the ribs are horseshoe-shaped, hollow; they radiate from a point a little below the apex, increase in size toward the periphery, and extend for as much as one-fourth their length past the edge of the shell proper. On larger forms the ribs are ragged

and broken by growth lines. The inner surface of the shell is minutely punctate; there is no interior reflection of the ribs. A faint impression in the shell interior on each side of the apex suggests muscle scars.

Dimensions of holotype: greatest diameter, 3.2 mm; height at the apex, 1.3 mm.

Holotype, no. 46058; paratypes, no. 46059.

Remarks.—This distinctive shell is placed in a new genus based principally on the ornamentation, with the strong radial ribs as the outstanding feature. Common in the material.

Genus PUNCTOPATELLA Grubbs, n. gen.

Moderately low, nonspiraled, cone-shaped patellids commonly with a subcentral apex; shell substance with the appearance of several imbricating layers, each layer reticulated by regularly arranged circular punctae; muscle impressions on each side of the apex.

Genotype, *Punctopatella corallifera* Grubbs, n. sp.

Remarks.—The shape of the shell in this genus resembles *Propatella* Grubbs and several species of *Palaeacmaea* Hall. The punctate nature of the shell is the distinguishing characteristic.

PUNCTOPATELLA CORALLIFERA Grubbs, n. sp.
Plate 62, figures 31, 33, 34

Shell a small cone, subcircular or slightly ovid in outline, margin in some cases irregular or roughly lobed. Apex high, nonspiraled, eccentric, nearer to and slightly incurved toward the posterior. Shell wall with the appearance of multiple layers, each layer reticulated by numerous circular punctae; outer surface bears occasional imbricating concentric growth lines, which tend to curl slightly. The shell is somewhat thickened on the inner edge of the periphery to form an inner ring or lip. Shell interior minutely punctate, with faint muscle impressions on each side of the apex.

Dimensions of holotype: greatest diameter, 2.2 mm; height at apex, 1.3 mm.

Holotype, no. 46060; paratypes, no. 46061.

Remarks.—This shell resembles closely *Propatella magnacostata* Grubbs in outline and features of shape; the interior features are also similar. The external surface of this species roughly resembles a colonial coral because of the regular spacing of the circular punctae.

Phylum ARTHROPODA
Class OSTRACODA
Genus BEYRICHIA McCoy, 1846
BEYRICHIA GREGARIA Grubbs, n. sp.
Plate 62, figures 35–39

Carapace large, oblong-subquadrate in outline, obese, cardinal extremities well defined. Hinge line straight, dorsal margin straight except where modified by anterior and posterior lobes; ventral margin gently convex, its greatest convexity in the posterior quarter. Anterior outline broadly curved toward venter, slightly flattened toward dorsum, joins the hinge line at an angle of a little more than 90°; posterior outline more obliquely curved toward the venter, flattening toward the dorsum, with a slight concavity below the cardinal angle; posterior cardinal angle somewhat greater than the anterior. Carapace highest somewhat behind the midline, its greatest thickness below and anterior to midpoint. Valves subequal, both valves marked with strong, sharp, false keels, which parallel the venter, are reduced toward and die out near the hinge line. Hinge simple.

Valves with a roughly bilobate aspect, but the posterior lobe is modified by the development of a smaller third lobe, which occupies the median position on the carapace. The anterior lobe is the larger, occupying most of the anterior half of the carapace and protruding as a curved ridge slightly above the dorsal margin. Median lobe a slightly bulbous protuberance located above and behind the midarea of the shell, somewhat diagonally elongated in a posterodorsal–anteroventral direction, and connected to the anterior lobe by a slightly expanded extension, which passes underneath a median sulcus. Median lobe separated laterally from the anterior lobe by the median sulcus, which extends a short distance into the ventral half of the carapace and dies out into the dorsal margin. Sulcus deeply incised below, shallow above, flared at the dorsal margin. The median lobe is

separated from the posterior lobe by a shallow, poorly defined sulcus. Posterior lobe less inflated than the anterior, protrudes above the hinge line as a bluntly angular projection subequal in height to dorsal extension of anterior lobe.

Females of this species show, along the posteroventral margin, a large, bulbous, somewhat elongate brood pouch, which extends anteriorly a short distance beyond midcarapace.

The surface is smooth except for shallow pits, which apparently are the result of irregular replacement of the original shell material by silica.

Dimensions of holotype: length, 2.8 mm; height, 1.6 mm; thickness, 1.8 mm. Average length of female brood pouch, 1.0 mm.

Holotype, no. 46062; paratypes, no. 46063.

Remarks.—This species resembles *B. klodeni* McCoy in the development of the brood pouch. In general shape and appearance it is similar to *B. moodeyi* Ulrich and Bassler and *B. veronica* Ulrich and Bassler but lacks the marginal fringe developed by these species, and the brood pouch is not as large and is restricted more to the posterior. *B. gregaria* differs from these and other described species in the presence of the dorsal projections of the anterior and posterior lobes.

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OSTRACODA FROM THE WECHES FORMATION AT SMITHVILLE, TEXAS

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ABSTRACT—Nineteen species of Ostracoda are described from the middle portion of the Weches formation at Smithville, Texas. They are classified into five genera including two subgenera of *Cytheridea*. Eighteen of the species and one subgenus (*Phractocytheridea*) are new.

THIS paper considers the ostracod microfauna of the Weches formation at Smithville, Texas. The Weches formation, where it crops out along the banks of the Colorado River at Smithville, Bastrop County, Texas, is abundantly fossiliferous and is one of the more famous collecting spots for Tertiary fossils in this country, yet no papers have been published on the microfauna except a list of 24 species of foraminifera by Mrs. Helen Jeanne Plummer (in Sellards, 1932, p. 645), and a paper by Cushman and Thomas (1929) on the foraminifera. The portion of the Weches represented by the outcrop at Smithville is the middle and upper zones of the formation. Our samples were collected from the middle zone (bed 6 in section) by A. H. Sutton and C. B. Claypool in 1933.

SECTION OF THE WECHES AT SMITHVILLE, TEXAS
(SELLARDS, 1932, p. 640)

	Feet
12. Marl, green, glauconitic, fossiliferous	2
11. Greensand, indurated, fossiliferous	1
10. Marl, brownish black, fossiliferous, glauconitic	1½
9. Limonite, or indurated, weathered glauconite	½
8. Marl, brown, laminated, fossiliferous	4
7. Limonite, very hard, fossiliferous	2
6. Marl, green, glauconitic, fossiliferous	5
5. Limonite, or indurated, weathered glauconite	1
4. Marl, green, laminated, fossiliferous	1
3. Unexposed	10
	27½

About 20 feet beneath the bottom of this section at the mouth of Gasley Creek about 1600 feet west of the bridge and separated from the above section by a small fault and unconformity, a soft, white shell marl crops out at low water, if not covered by river mud. The section may be continued as follows:

2. Marl, mostly green highly glauconitic,	20±
1. Sand, white, medium grained. Beach sand containing a bed made up of a shell bank of white pelecypods belonging to the genus *Pitaria* and containing about 12 species of fossils, which have been described by Katherine Palmer. Some of the shells are eroded by waves (?)	3
Total thickness of Weches formation at Smithville.	57±

The Weches formation belongs to the Claiborne group of the Eocene. The name was proposed in 1929 by Wendlandt and Knebel (1929, p. 1356) for the glauconitic bed lying between the Queen City sand and the Sparta sand. Previously this had been known under various names, as a part of the Cook Mountain, Mount Selman, or Yegua formations. The type locality of the Weches has not been definitely chosen. The Weches formation is composed chiefly of glauconite and glauconitic clay. It crops out in a narrow discontinuous belt from Cass County in extreme northeast Texas southwestwardly through Leon, Bastrop, Gonzales, and Frio Counties. Southwest of Frio County the Claiborne strata above Queen City sand have not been differentiated so that the exact outcrop area in southwest Texas is not known.

The sediments of the Weches were deposited in shallow clear marine waters. The thick beds of glauconite, as in the Smithville section, which contain abundant perfectly preserved fragile shells indicate an offshore facies where little coarse sediment was deposited. This is exemplified by our sample from Smithville. Here the Ostracoda and Foraminifera are usually perfect original shells. The rest of the sample consists of pure glauconite sand.

Illustrations for this paper were prepared under the supervision of the senior author by C. de Jean Hercules. Types of all described specimens are deposited in the paleontological collection of the Department of Geology and Geography, University of Illinois.

SYSTEMATIC DESCRIPTIONS

Order OSTRACODA Latreille
Suborder PLATYCOPA Sars, 1866
Family CYTHERELLIDAE Sars, 1866
Genus CYTHERELLA Jones, 1849

Carapace in side view ovate or subovate; compressed, especially in front; greatest width or convexity of shell varies in different species from about the middle backward to the posterior extremity. Right valve conspicuously larger than left and overlapping it around entire margin. Hinge structure consists of a simple groove along the dorsal margin of the larger right valve, into which fits a simple flangelike ridge of the left valve. Surface smooth or punctate, never roughly sculptured (Alexander, 1929, p. 47).

Genotype *Cythere compressa* (Münster).

CYTHERELLA FIMBRICINCTUS Sutton and Williams, n. sp.
Plate 64, figures 14, 15

Carapace ovate in side view. Greatest height at the middle. Dorsal and ventral margins strongly and evenly arched. Anterior and posterior ends broadly and equally rounded. A flat rim, which is narrow around the ends and broad around the dorsal and ventral margins, projects entirely around the right valve. The left valve lacks this feature. Surface of the valves smooth, with widely scattered indistinct punctae. Viewed from above, the greatest thickness is near the posterior end of the carapace. From the point of greatest thickness the carapace thins rapidly and evenly to the anterior end. The right valve is much larger than the left and overlaps it strongly around the entire margin. The hinge consists of a shallow groove along the interior margin of the right valve, into which the margin of the left valve fits. The greatest amount of overlap of the valves is along the dorsal and ventral margins.

Right valve, syntype, U. I. X—1243, length 0.73 mm, height 0.50 mm; left valve, syntype, U. I. X—1242, length 0.62 mm, height 0.43 mm.

Suborder PODOCOPA Sars, 1866
Family CYTHERIDAE Baird, 1850
Genus CYTHEREIS Jones, 1849

Carapace highest at the anterior end, with more or less abrupt downward curve or slope immediately behind the high rounded anterodorsal angle. The hinge margin is straight, with the exception of this down curve at the anterior end. Left valve larger than the right but overlaps it conspicuously only at the high anterodorsal angle. Ventral margin straight or nearly so, subparallel to the dorsal margin, the two converging but slightly toward the posterior end. Anterior end broadly rounded and denticulate along the lower one-half or two-thirds of its length, and with a more or less strongly thickened and elevated rim in most species. Posterior end strongly compressed, more or less distinctly triangular in shape, obliquely truncated above and denticulate below. Posterior end, like the anterior, with a thickened marginal rim in most species. Carapace usually widest at the ventral margin, with the ventral surface flat and forming right or more or less acute angles with the lateral surfaces of the valves. Dorsal surface much narrower than the ventral, flat, and in most members of this genus increasing gradually in width toward the posterior end. A transverse section of the carapace is roughly quadrate.

The hinge structure of the right valve consists of a strong knoblike anterior tooth and a posterior tooth, which is either rounded and knoblike, or only slightly elongated and compressed. In some species the posterior tooth has the form of a serrate ridge like that of *Brachychthere*. Immediately behind the anterior tooth is a deep socket. The hinge margin between this socket and the posterior tooth bears a shallow groove, above which the dorsal edge of the valve projects slightly as a low, narrow ridge or bar. The hinge margin of the left valve bears a deep anterior socket, a strong knoblike, postjacent tooth, and another socket at the posterior end. The tooth lies below but is attached to the dorsal edge of the valve. Between the terminal elements of the hinge line, the dorsal edge of the valve is elevated to form a high, narrow bar or ridge.

Genotype *Cythereis ornatissima* (Reuss).

CYTHEREIS SPINOSA Sutton and Williams, n. sp.
Plate 63, figures 1–4

The left valve is subquadrate in lateral view, the right valve somewhat more elongate. In the left valve the dorsal and ventral margins are straight and nearly parallel, and in the right valve the dorsal margin is straight and the ventral slightly sinuate. Viewed from above, the carapace is elongate-ovate. The greatest thickness is about midway of the posterior half of the carapace. From this point the carapace thins regularly to the anterior end, which is broadly and evenly rounded. There are about 20 closely set, short spines, which completely encircle the anterior of the right valve. The spines of the left valve are confined to the lower two-thirds of the margin. The posterior end is sharply angulate at the posterodorsal angle. From this angulation the margin slopes obliquely to the ventral margin. The marginal area around the posterior end is visible from the outside of the valve. The posterior end, below the dorsal angulation, bears about eight spines, which traverse the marginal area and protrude beyond the margin of the valve. The dorsal margin bears a number of low nodes, but the ventral margin is only slightly nodose. The surface of the carapace is heavily studded with low spines and nodes. A line of about six low spines extends upward and backward toward the posterodorsal angulation from near the middle of the ventral margin. This is evident in both valves, although in the left valve these are commonly vertically elongate nodes, the third of which is usually more elongate than the others.

The ventral margin is flanged near the middle. The hinge line of the right valve is equipped with a high conical anterior tooth, behind which lies a deep, elliptical socket, and a high, knoblike posterior tooth. Between these the dorsal edge of the valve consists of a narrow groove. The hinge line of the left valve has a deep anterior socket and, postjacent, high smooth tooth and a deep elliptical posterior socket. Between the anterior and posterior ends of the hinge the dorsal edge of the valve is thinned to form a bar. The sockets, tooth, and bar fit into the corresponding elements of the right valve.

Right valve, paratype, U. I. X—1223, length 0.80 mm, height 0.43 mm; left valve, paratype, U. I. X—1224, length 0.77 mm., height 0.48 mm; complete carapace, holotype, U. I. X—1222, greatest thickness 0.40 mm.

CYTHEREIS SPLENDENS Sutton and Williams, n. sp.
Plate 63, figures 12–14

Carapace elongate, shell translucent. Greatest height at the anterior cardinal angle. Dorsal and ventral margins straight in the left valve, dorsal margin straight and ventral, somewhat sinuate in the right valve. The dorsal and ventral margins converge slightly toward the posterior. Anterior end broadly rounded and closely set with about 20 short, stubby spines. A glassy eye spot is present at the anterodorsal angle. A prominent rim extends from this eye spot to the ventral margin, parallel to the anterior end. Posterior end narrower than the anterior and with a prominent angulation at the posterodorsal margin. About five short spines around the posterior end. Surface of the carapace irregularly nodose. Just anterior to the middle of the valves is a larger, more prominent node, and a line of nodes extends from near the junction of the anterior and ventral margins obliquely backward and upward toward the posterior angulation. The carapace is elongate in dorsal view, the valves greatly compressed, most so at the ends.

From inside, the valves are moderately deep, with broad marginal areas, especially around the anterior end. The radial pore canals are numerous, usually grouped in pairs. The hinge of the right valve is straight, occupying the entire dorsal margin from the ocular spot to the posterodorsal angle. It consists of a high, rounded anterior tooth, behind which is a shallow socket and an elevated, blunt tooth at the posterior end. Between the anterior and posterior teeth the edge of the dorsal margin of the valve is finely grooved. The left valve has an anterior socket and tooth and posterior socket, which fit the corresponding elements of the right valve. Between the anterior socket and posterior socket and tooth, the dorsal margin is thinned to fit into the

corresponding groove of the right valve. Muscle scars not observed.

Right valve, paratype, U. I. X—1226, length 0.83 mm, height 0.40 mm; left valve, paratype, U. I. X—1227, length 0.83 mm, height 0.43 mm; complete carapace, holotype, U. I. X—1225, thickness 0.33 mm.

CYTHEREIS SMITHVILLENSIS Sutton and Williams, n. sp.
Plate 63, figures 18–20

The carapace is elongate in side view, with parallel dorsal and ventral margins. The dorsal margin has short, weakly developed spines. The anterior end is broadly rounded, with the lower two-thirds studded with close-set, short spines. The posterior end has a distinct angulation where it joins the dorsal margin. This angulation is somewhat more produced in the right valve than in the left. The posterior end slopes anteriorly to the ventral margin from this angulation, and has six to ten short spines, which are confined to the portion below the angulation in the right valve. The surface of the carapace is very rough and covered with welts, bumps, and numerous long, sharp spines. In most specimens nearly all of these sharp and delicate spines have been broken off, leaving their bases as a network of intersecting ridges. At the anterior cardinal angle is a prominent glassy eye spot. The greatest thickness is slightly posterior to the middle. A ridge, broken into a series of large nodes, borders and parallels the anterior end of the carapace.

From inside, the valves are moderately deep. The marginal area is rather broad, especially around the anterior end. The radial pore canals are numerous and closely spaced around the anterior end, and more widely spaced in the ventral and posterior marginal areas. They are grouped in pairs, commonly one pair to a spine. The hinge structure is characteristic of the genus.

Right valve, syntype, U. I. X—1228, length 0.90 mm, height 0.42 mm; left valve, syntype, U. I. X—1229, length 0.88 mm, height 0.43 mm.

Remarks.—This species is quite like *Cythereis splendens* n. sp. in general shape, but differs in several important respects. The dorsal and ventral margins of *C. smithvillensis* are parallel, but those of *C. splendens* converge gently to the posterior. *C. splendens* has high spines along the dorsal margin, but *C. smithvillensis* has only low node-like spines. The surface of the latter species is covered with an intricate network of intersecting ridges, but *C. splendens* has only scattered spines over the surface.

EXPLANATION OF PLATE 63

All illustrations ×40

FIGS. *1–4*—*Cythereis spinosa* Sutton and Williams, n. sp. *1*, Exterior left valve, paratype, U. I. X—1224. *2*, *3*, Exterior and interior right valve, paratype, U. I. X—1223. *4*, Dorsal view holotype, U. I. X—1222. (p. 563)

5, *6*—*Cythereis linospinosa* Sutton and Williams, n. sp. Exterior views of syntypes; *5*, left valve, U. I. X—1237; *6*, right valve, U. I. X—1236. (p. 566)

7–9—*Cythereis bursilloides* Stadnichenko. *7*, Exterior left valve, hypotype, U. I. X—1241. *8*, Exterior right valve, hypotype, U. I. X—1240. *9*, Dorsal view complete carapace, hypotype, U. I. X—1239. (p. 567)

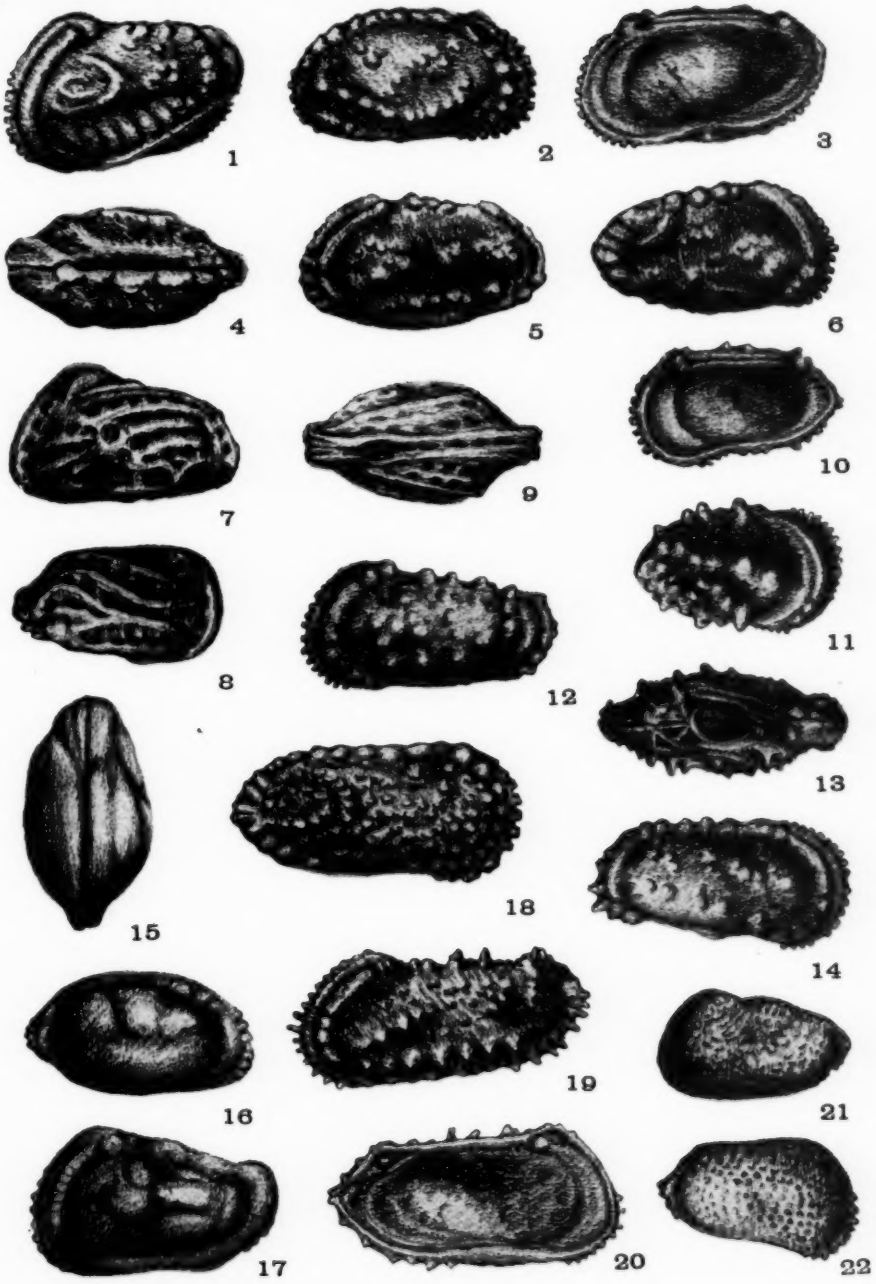
10, *11*—*Cythereis quinquespinosa* Sutton and Williams, n. sp. Interior and exterior right valve, holotype, U. I. X—1238. (p. 566)

12–14—*Cythereis splendens* Sutton and Williams, n. sp. *12*, Exterior left valve, paratype, U. I. X—1227. *13*, Dorsal view holotype, U. I. X—1225. *14*, Exterior right valve, paratype, U. I. X—1226. (p. 563)

15–17—*Cythereis sinuata* Sutton and Williams, n. sp. *15*, Dorsal view holotype, U. I. X—1232. Exterior views of paratypes; *16*, right valve, U. I. X—1233; *17*, left valve, U. I. X—1234. (p. 565)

18–20—*Cythereis smithvillensis* Sutton and Williams, n. sp. Syntypes. *18*, Exterior right valve, U. I. X—1228. *19*, *20*, Exterior and interior left valve, U. I. X—1229. (p. 564)

21, *22*—*Cythereis fragillissima* Sutton and Williams, n. sp. Exterior views of syntypes; *21*, left valve, U. I. X—1231; *22*, right valve, U. I. X—1230. (p. 565)



Sutton and Williams, Eocene Ostracoda

UNIV. OF MICH.

CYTHEREIS FRAGILLISSIMA Sutton and Williams, n. sp.
Plate 63, figures 21, 22

Carapace elongate in side view. Highest at the broadly rounded anterior end. About 20 closely set short spines around the anterior end, a lesser number around the posterior. Dorsal margin essentially straight, slightly sinuate near the middle and converging gently toward the posterior. Posterodorsal margin angulate. The posterior end slopes obliquely and evenly to the ventral margin from the point of angulation. The anterior two-thirds of the ventral margin is slightly sinuate. Along the posterior one-third of the valve, the margin slopes upward obliquely to the posterodorsal margin. A slight flange occurs near the middle of the ventral margin of each valve. Surface thickly covered with shallow pits, which resemble flax seeds and are arranged in rows roughly parallel to the margins of the valve. These pits vary in shape from circular to elongate-oval. In some specimens a glassy eye spot is present at the anterodorsal margin. Greatest thickness about two-thirds of the distance from the front. A small, short spine, visible only when the carapace is viewed from above, is directed posteriorly at the point of greatest thickness. Just anterior to the greatest thickness is a shallow sulcus, oblique to the direction of elongation of the valve.

From the inside the valves are moderately deep. The pits show clearly through the thin, fragile shell. Marginal area very narrow and radial pore canals spaced about one to a spine. Muscle scars not plainly discernible. Hinge features of the right valve delicate. Hinge straight, occupying about four-fifths of the dorsal margin, with a tiny crenulate, elongate cusp at each end. A fine groove connects the terminal cusps. Left valve toothless, with terminal sockets to receive the cusps of the right valve. These sockets are connected by a thin bar, which is not separate from, but is merely the thinned edge of the dorsal margin of the valve.

Right valve, syntype, U. I. X—1230, length 0.63 mm, height 0.33 mm; left valve, syntype, U. I. X—1231, length 0.60 mm, height 0.33 mm.

CYTHEREIS SINUATA Sutton and Williams, n. sp.
Plate 63, figures 15–17

The left valve is subquadrate in side view, the right suboval. The dorsal margin is straight, and the ventral margin slopes gently to the posterior. The anterior end is broadly rounded, with the lower two-thirds set with short, closely spaced spines. An elevated rim extends around the anterior end just behind the margin. The valves are angulate at the posterodorsal angle. The posterior margin slopes sharply to the ventral margin from this angulation. The margin is denticulate below the posterior angulation. The greatest height of the left valve is at the anterior cardinal angle. The greatest height of the right valve is near the middle, where the valve bulges. Viewed from above, the carapace is subquadrate and thickest posterior to the middle. The surface of the valves is smooth and glassy, and a series of broad, low, gentle folds cross the carapace longitudinally. A prominent glassy eye spot is located at the anterior cardinal angle. Along the dorsal margin of the left valve are several indistinct nodose swellings.

From inside, the valves are deep. The marginal areas are rather broad around the ends. The radial pore canals are rather thin and grouped in pairs, spaced one pair to a spine. The ventral margin is flanged near the middle. The hinge line of the right valve is composed of a high anterior tooth, a postjacent deep socket, and a high, conical posterior tooth. A narrow groove connects these elements. The hinge of the left valve consists of a deep anterior socket, behind which is a high, conical tooth and a deep elliptical posterior socket. The dorsal margin of the valve is thinned to form a narrow bar between these.

Right valve, paratype, U. I. X—1233, length 0.73 mm, height 0.43 mm; left valve, paratype, U. I. X—1234, length 0.80 mm, height 0.47 mm; complete carapace, holotype, U. I. X—1232, thickness 0.42 mm.

CYTHEREIS? ELONGATA Sutton and Williams, n. sp.
Plate 64, figures 31–33

Carapace elongate, subrectangular. Great-

est height at the extreme anterior end. Dorsal and ventral margins straight, converging very slightly toward the posterior. Anterior end broadly and evenly rounded, with no spines. Posterior end slightly angulate at the posterodorsal angle. Below this point the margins of the valves slope downward obliquely to the ventral margin. The carapace is elongate-pyramidal in shape in dorsal view. The greatest thickness occurs about one-fifth of the length from the posterior end. From the point of greatest thickness the carapace is very strongly compressed to the posterior end. Dorsally the carapace has a shallow triangular depression, the apex of which is directed toward the posterior. The dorsal margin is slightly raised above the ocular spot. Viewed ventrally the carapace has the same shape as when viewed dorsally, except that the entire ventral surface is flat. Anterodorsal angle with a glassy eye spot. Surface of the valves covered with an inconspicuous mesh of reticulate ridges. One particularly prominent ridge extends obliquely across the valve from just above the greatest thickness, slopes downward to the anterior, and ends at a point vertically below the eye spot. Hinge structure unknown, as only three complete specimens are known of this species.

Complete carapace, holotype, U. I. X—1235, length 0.58 mm, height 0.29 mm, thickness 0.27 mm.

CYTHEREIS LINOSPINOSA Sutton and Williams, n. sp.
Plate 63, figures 5, 6

Carapace subquadrate in side view. Dorsal margin straight, sloping very slightly to the posterior; ventral margin slightly arcuate. The anterior end is broadly rounded, with about 20 short spines around the right valve and about 10 short spines in the lower one-half of the anterior end of the left. The anterior end of each valve possesses a raised rim. The posterior end is irregularly nodose, sharply angulate, and slopes abruptly from this angulation to the ventral margin. The margins of the valves, except the ventral margin of the left valve, are irregularly nodose. The surface of the carapace is covered with scattered spines and nodes, with an especially prominent nodose area just anterior to the middle of each valve. There is a prominent glassy eye spot at the anterior cardinal angle.

From inside, the valves are moderately deep. The marginal areas are fairly broad around the ends. The radial pore canals are grouped in pairs, one pair to each spine. The hinge line of the right valve has a high anterior tooth and postjacent deep socket, and a high, conical posterior tooth. A shallow groove connects these elements. The hinge line of the left valve has a deep anterior socket, behind which is a high, pointed tooth and a deep elliptical socket at the posterior end. Between the anterior and the posterior hinge elements the dorsal margin is thinned to form a bar, which fits into the corresponding groove of the right valve.

Right valve, syntype, U. I. X—1236, length 0.73 mm, height 0.40 mm; left valve, syntype, U. I. X—1237, length 0.77 mm, height 0.43 mm.

CYTHEREIS QUINQUESPINOSA Sutton and Williams, n. sp.
Plate 63, figures 10, 11

The carapace is elongate and ovate, with the valves flatly compressed, with the greatest height at the anterior cardinal angle. The dorsal and ventral margins are straight and converge posteriorly. The anterior end is broadly rounded, with about 16 closely set stubby spines. The posterodorsal portion of the posterior end is sharply angulate, and from this angulation the margin slopes abruptly to the ventral margin. The ventral margin, from the juncture of the anterior margin to the posterodorsal angulation, has about 16 spines, which are about three times as large as those around the anterior end. The dorsal margin has four distinct spines, which point very slightly backward. The surface of the carapace is smooth and glassy, with a number of scattered low spines. A linear arrangement of about five more prominent low spines extends from the posterior end of the dorsal margin across the carapace almost to the junction of the anterior and ventral margins. There is a prominent glassy eye spot at the anterior cardinal angle. From this eye spot, a line of seven nodes parallels the anterior end to its junction with the ventral margin. The greatest thickness is near the middle.

From inside, the carapace is rather shallow. The marginal area is broad around both ends. Radial pore canals are numerous and closely spaced. The hinge of the right valve has an anterior high conical tooth and postjacent socket, and another high smooth, glassy, conical tooth at the posterior end, with a narrow groove between the anterior socket and posterior tooth. This species is known only from the right valve, which is translucent and light brown in color.

Right valve, holotype, U. I. X—1238, length 0.67 mm, height 0.37 mm.

CYTHEREIS BURSILLOIDES Stadnichenko
Plate 63, figures 7–9

Cythereis bursilloides STADNICHENKO, *1927*, Jour. Paleontology, vol. 1, no. 3, p. 239, pl. 39, figs. 21–23.

Carapace subquadrate in side view, with the dorsal and ventral margins sloping only slightly to the posterior. Greatest height at the anterior cardinal angle. Anterior end squarely rounded. The posterior end sharply angulate at the dorsal margin; below this angulation the carapace is somewhat produced to form a small, rudderlike projection. This projection has several short spines. Viewed from above, the greatest thickness is in the posterior one-half of the carapace. From the point of greatest thickness the carapace thins regularly to the anterior end. The surface of the carapace is covered with a reticulate network of ridges. At the anterior cardinal angle is a prominent glassy eye spot.

Interior of the carapace rather deep. The hinge of the right valve consists of a projecting conical tooth, postjacent to which is a deep socket and a high, projecting tooth at the posterior end. Between these, the dorsal margin is thinned to form a bar. In the left valve the hinge consists of a deep anterior socket, immediately posterior to which is a high conical tooth and a deep elliptical posterior socket. Between these elements the dorsal edge of the valve is grooved.

Complete carapace, hypotype, U. I. X—1239, thickness 0.40 mm; right valve, hypotype, U. I. X—1240, length 0.67 mm, height 0.37 mm; left valve, hypotype, length 0.73 mm, height 0.43 mm.

Remarks.—Miss Stadnichenko reported this species from the Crockett (Yegua) formation at Evergreen crossing, Moseley's Ferry and Orell's Ferry, Lee County, Texas. It is rather rare at Smithville.

Genus PYRICYTHEREIS Howe, 1936

Carapace in side view pyriform. Viewed dorsally, elongate ovate. The dorsal and ventral outlines both slightly convex and converging toward the posterior. The anterior broadly and obliquely rounded. Posterior narrower, rounded, and, in the left valve, forming a pronounced angulation where it joins the dorsal margin and overlaps the posterior cardinal tooth of the right valve. Surface variously ornamented with pits and ridges, which are usually arranged more or less parallel to the margins or almost smooth. The anterior margin usually bears a series of rims parallel to it. Viewed from the inside the valves are rather deep, the greatest thickness being behind the middle. Marginal areas are broad with very numerous radial pore canals in the ventral two-thirds of the anterior and a smaller number around the posterior. The hinge is similar to *Cythereis*, but the groove which parallels the dorsal margin of the right valve is distinctly crenulate as is the hinge bar of the left valve (Howe and Law, 1936, pp. 65–66).

Genotype *Cythereis israelskyi* Howe and Chambers.

PYRICYTHEREIS FOVEOVALVA Sutton and Williams, n. sp.
Plate 64, figures 29, 30

The carapace is elongate and subrectangular in side view. The dorsal margin is straight, except near the ocular spot, where it is sharply convex. The ventral margin is nearly straight, with a slight concavity. The dorsal and ventral margins are essentially parallel. The anterior end is broadly and evenly rounded. There is a very strong angulation at the posterodorsal margin, which extends from there to the middle of the posterior margin. From here the posterior margin is strongly convex to the ventral margin. From the outside of the valve, radial pore canals are distinctly visible around the anterior end and the lower half of the posterior margin. The greatest thickness is posterior to the middle. The surface is covered with elongate pits, which are arranged in radiating circles around a point just anterior to the middle. At the anterodorsal margin there is a glassy eye spot.

The interior of the valve is rather deep. Around the ends, the marginal area is broad and crossed by numerous closely spaced ra-

dial pore canals. The hinge of the right valve is equipped with a high anterior tooth, with a shallow socket immediately behind it and a raised posterior tooth, which is about twice as long as high. The surface of the posterior tooth has about six crenulations. Between the terminal teeth there is a narrow, faintly crenulate groove. This species is very rare and only one right valve is known.

Right valve, holotype, U. I. X—1244, length 0.66 mm, height 0.32 mm.

PYRICYTHEREIS DELICATA Sutton and Williams, n. sp.
Plate 64, figures 5–7

The carapace is very small, delicate, and subquadrate in side view. The dorsal margin is straight and sharply angulate at both ends. Below the angulation the anterior margin is evenly rounded to the ventral margin. The posterior end slopes abruptly from the dorsal angulation to the ventral margin. Around the margins of the valves are shelflike rims, which project beyond the tumid portion of the carapace and are more prominent at the ends. The dorsal and ventral margins are straight and parallel. Viewed from above, the carapace is elongate-oval, even tumid, with the greatest thickness near the middle. The projecting rims on the ends, when the carapace is viewed from above, appear as short, rudderlike projections. The surface of the carapace is covered with a delicate, intricate pattern of intersecting reticulations.

The valves are moderately deep interiorly. The marginal area is broad around the ends of the valve. A thin knife-edge ridge extends from the outer edge of the anteroventral margin, where it immediately crosses over to the inner edge of the ventral margin, and continues to the posterodorsal angulation. It is presumed that this assisted in articulation of the valves. The hinge of the right valve is delicate. At the anterior end is a small conical, knoblike tooth, which is notched at the top. Back of this is a small socket, and at the posterior end of the hinge is a projecting tooth, which is somewhat elongate and notched at the top. Between these elements is a narrow groove. No unarticulated left valves of this species have been studied.

Complete carapace, holotype, U. I. X—1245, thickness 0.23 mm; right valve, paratype, U. I. X—1246, length 0.37 mm, height 0.23 mm.

PYRICYTHEREIS SMITHVILLENSIS Sutton and Williams, n. sp.
Plate 64, figures 16–19

The carapace is elongate-rectangular in side view and highest at the anterior cardinal area. The dorsal and ventral margins are straight and converge toward the posterior, with the ventral margin converging more sharply than the dorsal. The anterior end is broadly rounded, somewhat more acutely in the lower one-half. The lower half possesses closely spaced short spines. There is a broad, flat, shelflike rim around the anterior end, through which the radial pore canals are plainly visible. The posterior end is angulate to about the middle, from which point it slopes abruptly to the ventral margin. On some specimens the lower half of the posterior end is sparingly denticulate, although more often it is edentate. The flat shelflike projection around the posterior end is not as broad as that of the anterior end. Viewed from above, the carapace is elongate-oval, with the greatest thickness at a point about three-quarters of the distance from front to back. From the point of greatest thickness the carapace is gently compressed to the posterior end and narrowed gently and regularly to the anterior end. The valves are equal in size. The top of the carapace is flat, and along the center line of the dorsal margins is a shallow, elongate-elliptical depression. The surface of the carapace is marked by a series of longitudinal ribs, which are sparingly connected by faint cross riblets. In the upper half of the carapace the ribs are convex upward, in the lower half they are convex downward.

From inside, the valves appear rather deep. The marginal areas are broad and occur around the carapace except along the dorsal margin. They possess numerous closely spaced radial pore canals. The middle of the left valve has a flange. The hinge of the left valve has an anterior socket and, postjacent, a strongly elevated, conical tooth and a posterior, lenticular socket about three times as long as wide. Between these elements, the edge of the dorsal margin is thinned and crenulated. Just in front

of the posterior socket the hinge bar possesses four or five dentitions, which are more prominent than those of the remainder of the bar.

Complete carapace, holotype, U. I. X—1247, thickness 0.40 mm; left valve, paratype, U. I. X—1248, length 0.70 mm, height 0.37 mm.

PYRICYTHEREIS SUBTRIANGULARIS
Sutton and Williams, n. sp.
Plate 64, figures 11–13

Carapace subtriangular in side view. Dorsal margin nearly straight, with a slight convexity just posterior to the middle of the margin, due to a swelling of the carapace. The dorsal and ventral margins converge strongly toward the posterior. The greatest height of the carapace is at the anterior cardinal angle. From this point the anterior end is broadly and evenly rounded, and the posterior end angulate and strongly compressed. Around the anterior end there is a sharp, elevated rim, which parallels the margin from the anterior cardinal angle to the ventral margin. Viewed from above, the carapace is suboval and the valves equally tumid. The greatest thickness is near the middle of the posterior half. The surface of the carapace has a reticulate pattern of ridges, which intersect almost at right angles, producing a pitted appearance. At the point of greatest thickness there is a short spine, which projects posteriorly.

From inside, the valves are rather deep, with a narrow marginal area. The pits on the exterior of the valves are plainly visible from the inside. The hinge of the right valve has an anterior tooth, which is high, thin, blade-like, and elongate, with about eight crenulations on the top. Directly behind it is a shallow-elongate socket. The tooth at the posterior end of the hinge line is similar to the anterior one and is convex upward in side view. Between these teeth is a narrow finely crenulate groove. The hinge of the left valve is composed of an anterior socket, about three times as long as high, with a small, bladelike tooth behind it and a socket about three times as long as wide at the posterior end. The dorsal margin of the valve is crenulated between these.

Complete carapace, holotype, U. I. X—1249, thickness 0.33 mm; right valve, paratype, U. I. X—1250, length 0.52 mm, height 0.30 mm; left valve, paratype, U. I. X—1251, length 0.55 mm, height 0.42 mm.

Genus CYTHERIDEA Bosquet, 1852
Subgenus HAPLOCYTHERIDEA
Stephenson, 1936

Carapace tumid, in side view elongate, subovate. Left valve larger than the right and overlapping around the entire margin. Dorsal margin arched, somewhat angulate at the cardinal areas. Ventral margin almost straight. Both valves flanged along the ventral margin. Anterior end broadly rounded, posterior end rounded to obliquely truncate. Surface variously sculptured with ridges, nodes, and punctae. Interior of valves smooth, marginal areas usually broad, radial pore canals rather numerous. This subgenus is separated from *Cytheridea* (*Cytheridea*) on the basis of the hinge characters. According to Stephenson (1936, p. 700),

> The hinge of the right valve is composed of two elongate, taxodont dental areas, each of which is divided into several cusps by transverse notches. Between these terminal dentitions along the dorsal margin and separated from it by an almost imperceptible line, is a uniformly projecting line of equidimensional, minute crenulations. In the left valve the hinge has corresponding notched sockets, which are connected by a faint, narrow, longitudinal crenulate incision that lies immediately below and beneath the projecting edge of the dorsal margin.

In other than these hinge characters the two subgenera *Cytheridea* and *Haplocytheridea* agree.

Subgenotype *Cytheridea montgomeryensis* Howe and Chambers, 1935.

CYTHERIDEA (HAPLOCYTHERIDEA)
SUBOVATA Sutton and
Williams, n. sp.
Plate 64, figures 26–28

Carapace small and subovate in side view. Cardinal angles distinct. Dorsal margin strongly arched and acutely truncate from the posterior cardinal angle to the posterior end of the carapace. Greatest height in the right valve near the middle, in the left valve slightly anterior to the middle. Ventral margin straight. Anterior end broadly rounded. Posterior end acutely compressed, somewhat pointed. Surface

punctate, the punctae arranged in shallow transverse trenches, which are arcuate toward the front on the anterior portion and toward the back on the posterior part of the shell. Rather weakly developed ridges separate these trenches. Posterior end of right valve with three small short spines, which are fused at the base. Viewed from above, the carapace is elongate-oval in shape. Valves evenly and flatly tumid, with the greatest thickness at or slightly anterior to the middle. Teeth not visible in dorsal view of the right valve. Left valve overlaps the right around the carapace. A small flange is situated at the middle of the ventral margin of the valves.

Interior of the valves moderately deep. Inner lamella widest at the anterior end and prominent along the ventral margin. Radial pore canals straight and closely spaced, about 40 around the anterior end and 30 along the ventral margin. The right valve has terminal taxodont dental areas connected by a line of fine, evenly spaced crenulations. Anterior dental areas with ten teeth, which are vertically elongate and increase in length from the anterior to the posterior end of the dental area. Anterior dental area about eight times as long as high. Posterior dental area about six times as long as high and with six teeth. The plane of the dental areas slopes somewhat toward the interior of the shell, making the teeth appear more prominent at the outer edge of the valve. Hinge of the left valve with the features typical of *Haplocytheridea*. Terminal notched sockets connected by a line of notches. Edge of the carapace slightly overhands the line of connecting notches. Muscle scars obscure.

Complete carapace, holotype, U. I. X—1252, thickness 0.37 mm; left valve, paratype, U. I. X—1253, length 0.70 mm, height 0.43 mm; right valve, paratype, U. I. X—1254, length 0.77 mm, height 0.40 mm.

CYTHERIDEA (HAPLOCYTHERIDEA) HABROPAPILLOSA Sutton and Williams, n. sp.
Plate 64, figures 20–22

The carapace is subpyriform in side view and highest just anterior to the middle. The left valve is larger than the right and

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EXPLANATION OF PLATE 64

All illustration ×40 unless otherwise indicated

FIGS. *1–4—Cytheridea (Haplocytheridea?) subpyriformis* Sutton and Williams, n. sp. *1*, Exterior left valve, paratype, U. I. X—1259. *2, 3*, Exterior and interior right valve, paratype, U. I. X—1258. *4*, Dorsal view holotype, U. I. X—1260. (p. 571)

5–7—Pyricythereis delicata Sutton and Williams, n. sp. ×60. *5, 7*, Left lateral and dorsal views of holotype, U. I. X—1245. *6*, Exterior right valve, paratype, U. I. X—1246. (p. 568)

8–10—Cytheropteron minutum Sutton and Williams, n. sp. ×60. *8*, Exterior left valve, syntype, U. I. X—1263. *9, 10*, Exterior and interior right valve, syntype, U. I. X.—1264. (p. 573)

11–13—Pyricythereis subtriangularis Sutton and Williams, n. sp. *11*, Exterior left valve, paratype, U. I. X—1251. 12, Exterior right valve, paratype, U. I. X—1250. *13*, Dorsal view holotype, U. I. X—1249. (p. 569)

14–15—Cytherella fimbricinctus Sutton and Williams, n. sp. *14*, Exterior left valve, syntype, U. I. X—1242. *15*, Exterior right valve, syntype, U. I. X—1243. (p. 562)

16–19—Pyricythereis smithvillensis Sutton and Williams, n. sp. 16, 18, Exterior and interior left valve, paratype, U. I. X—1248. *17–19*, Right, lateral, and dorsal views, holotype, U. I. X—1247. (p. 568)

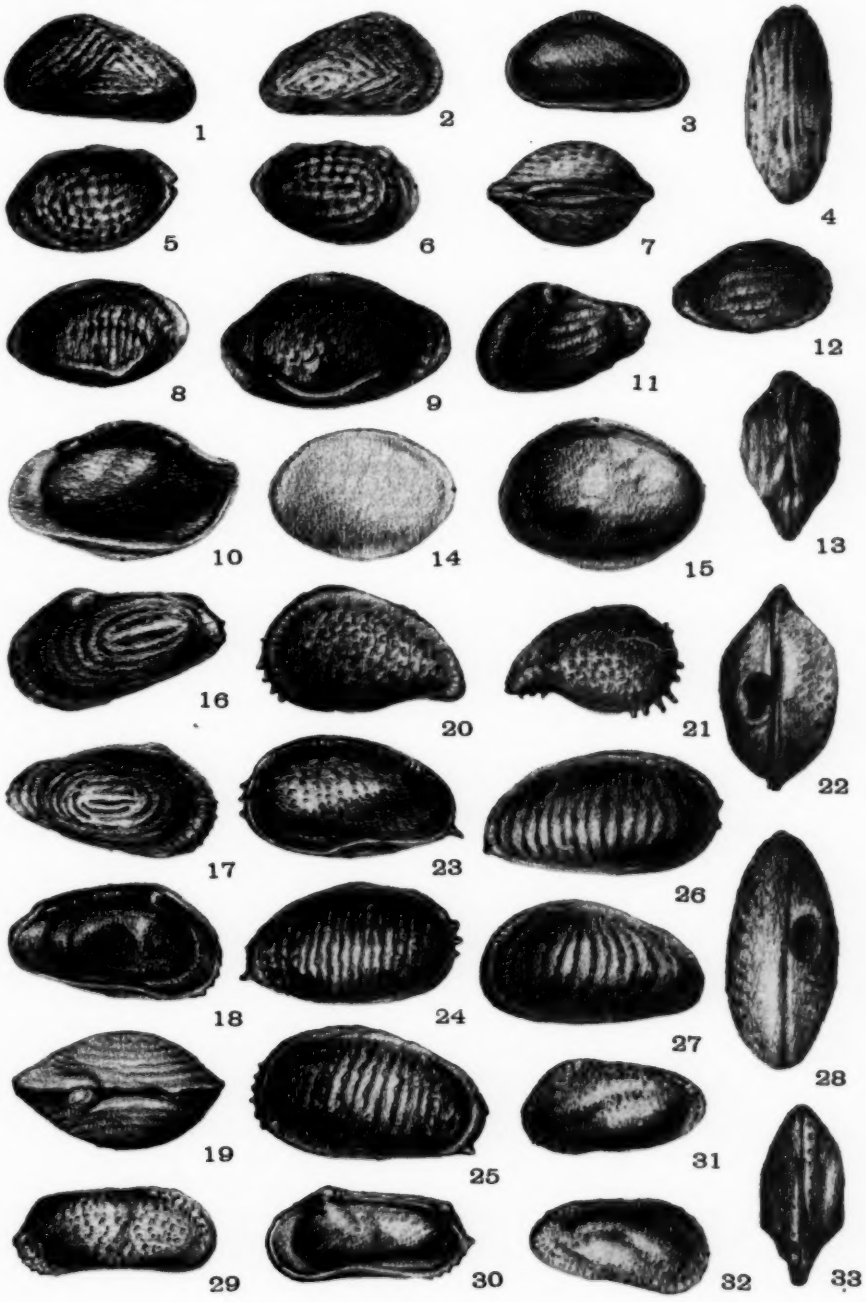
20–22—Cytheridea (Haplocytheridea) habropapillosa Sutton and Williams, n. sp. *20*, Exterior left valve, paratype, U. I. X—1256. *21*, Exterior right valve, paratype, U. I. X—1257. 22, Dorsal view holotype, U. I. X—1255. (p. 570)

23–25—Cytheridea (Phractocytheridea) compressa Sutton and Williams, n. sp. *23, 24*, Interior and exterior right valve, syntype, U. I. X—1262. *25*, Exterior left valve, syntype, U. I. X—1261. (p. 572)

26–28—Cytheridea (Haplocytheridea) subovata Sutton and Williams, n. sp. *26*, Exterior right valve, paratype, U. I. X.—1254. *27*, Exterior left valve, paratype, U. I. X—1253. *28*, Dorsal view holotype, U. I. X—1252. (p. 569)

29, 30—Pyricythereis foveovalva Sutton and Williams, n. sp. Exterior and interior of right valve, holotype, U. I. X—1244. (p. 567)

31–33—Cythereis? elongata Sutton and Williams, n. sp. Left, right, and dorsal views of the holotype, U. I. X—1235. (p. 565)



Sutton and Williams, Eocene Ostracoda

UNIV. OF MICH.

overlaps entirely around the carapace, more strongly along the dorsal margin. Viewed from above the carapace is elongate-oval in shape and thickest just posterior to the middle. The carapace slopes abruptly toward the posterior end of the valve from the thickest place. In side view the inner lamella, which is more prominent in the left valve, protrudes as a rim around the ends but is not visible along the dorsal or ventral margins. Anterior end sharply rounded, with about six sharp spines. Dorsal margin evenly and strongly arched. The posterior end slopes abruptly from the posterior cardinal angle to the ventral margin. Posterior end sharply pointed. Ventral margin sinuate. Surface of the valves strongly rounded and covered with distinct papillae. Near the center of the valves there is a cluster of about seven papillae. Additional papillae are arranged in concentric rings around the central cluster. Toward the extreme dorsal and posterior edges of the carapace they die out, and here the carapace is smooth. Ventrally they are replaced by three ridges, which parallel the ventral margin of the valve.

Interior of the valves deep. The margin of the left valve bears a narrow shelf, upon which the margin of the right valve rests. A slight flange occurs near the center of the ventral margin of the left valve. Hinge line straight, occupying about half of the dorsal margin. The right-valve hinge consists of terminal taxodont dental areas connected by about 15 smaller dentitions. The elliptical terminal areas are about four times as long as wide and contain seven vertically elongate teeth each. An incised line is situated just above the hinge line and between the terminal dentitions. Hinge of the left valve consists of two terminal, notched, indented sockets for the reception of the terminal teeth of the right valve. These sockets are connected by a line of notches. A straight, narrow bar, above which is a narrow incised groove, lies between the terminal sockets of the left valve. Muscle scars are not observable in any of the specimens.

Complete carapace, holotype, U. I. X—1255, thickness 0.40 mm; left valve, paratype, U. I. X—1256, length 0.67 mm, height 0.40 mm; right valve, paratype, U. I. X—1257, length 0.57 mm, height 0.37 mm.

CYTHERIDEA (HAPLOCYTHERIDEA?) SUBPYRIFORMIS Sutton and Williams, n. sp.

Plate 64, figures 1–4

Carapace subpyriform in side view and highest slightly anterior to the middle. Greatest height in the left valve is a little farther forward than in the right. Dorsal margin strongly arched, cardinal angles distinct. Ventral margin straight. Anterior end evenly rounded. Posterior end more narrowly rounded. Surface an irregular pattern of reticulate ridges. The carapace is elongate-oval in dorsal view, with the greatest thickness at the middle, and thins evenly toward the ends. Valves almost equal in size, left somewhat larger with an overlap along the ventral margin. Left valve with a slight flange on ventral margin. Hinge in the right valve straight, occupying about half the dorsal margin and conspicuously elevated, with terminal, taxodont dental areas. The dental areas project prominently in dorsal view, posterior more than anterior. Anterior dental area about four times as long as wide, convex outward, with about six vertically elongate teeth. Posterior dental area with about five teeth. Dental areas connected by a line of fine dentitions. An incised line above the hinge line separates the hinge from the dorsal margin of the carapace. The hinge line of the left valve consists of terminal sockets, which receive the teeth of the right valve. The dorsal edge of the valve overhangs the hinge between the sockets. The edge of the overhang is notched. A faintly incised line lies above this notched line. Interior of the valves moderately deep. Inner lamella narrow. Radial pore canals straight, evenly spaced, about 15 around the anterior end. Muscle scars obscure.

Right valve, paratype, U. I. X—1258, length 0.60 mm, height 0.33 mm; left valve, paratype, U. I. X—1259, length 0.63 mm, height 0.33 mm; complete carapace, holotype, U. I. X—1260, thickness 0.30 mm.

PHRACTOCYTHERIDEA Sutton and Williams, n. subgen.

Surface sculpture similar to that of the

subgenus *C. Haplocytheridea*. General valve shape as in *Cytheridea*. Hinge line of the right valve curved, following the dorsal margin of the carapace. Dorsal margin very thin, with terminal taxodont dentitions set like beads on it. Anterior and posterior dental areas with about six teeth. Hinge of the left valve consists of a shallow shelflike groove paralleling the dorsal margin for the reception of the hinge line of the right valve. Anterior and posterior sockets grooved for the reception of the teeth of the right valve. The anterior socket lies at the anterior end of the hinge shelf and the posterior socket just back of the shelf. These sockets are connected by the shallow, faintly notched hinge groove. The notches of the connecting groove and the anterior socket are so weakly developed that they are discernible only when the illumination is from a favorable angle. Inner margin of the anterior socket with an upcurling flange. Posterior socket with much stronger notches than the anterior. Muscle scar pattern of the right valve consists of a vertical row of four closely spaced pyriform scars with two separated scars vertically beneath. Two oblique scars lie anterior to the row of four.

This new subgenus agrees with other subgenera of *Cytheridea* except in the characters of the hinge line, which vary notably from the other described forms. The dorsal margin of the left valve of this subgenus does not project over the hinge line as in the subgenera in *Cytheridea* and *Haplocytheridea*. In contrast with *Cytheridea* and *Cleithrocytheridea* there is a faint crenulate groove connecting the terminal hinge sockets. The surface sculpture is strong, in contrast with the weakly ornamented exterior of *Leptocytheridea*. The line of hinge teeth in the right valve is not separated from the dorsal margin by an incised line as in *Cytheridea* and *Haplocytheridea*. In no other subgenus, so far as the authors know, is there a flange on the anterior dental socket.

Subgenotype *Cytheridea* (*Phractocytheridea*) *compressa* Sutton and Williams, n. sp.

CYTHERIDEA (PHRACTOCYTHERIDEA) COMPRESSA Sutton and Williams, n. sp.
Plate 64, figures 23–25

Carapace subovate in side view, highest anterior to the middle. Inner lamella projects distinctly around the carapace except in the posterior one-third of the ventral margin. Anterior end of the carapace evenly and broadly rounded, denticulate, especially on the lower half. Dorsal margin evenly arched. Cardinal angles faint. Posterior end slightly compressed and bluntly acute. The carapace is even and flatly arched and of constant thickness from front to back, in dorsal view. Teeth of the right valve project only slightly. Interior of valves moderately deep, smooth, and perforated by punctae, which pierce the shell. About seven denticulations on the lower one-half of the anterior end of the right valve. These are broken off in most specimens. One or two denticulations on most valves at the posteroventral margin. Carapace clear, translucent, and amber in our specimens. Carapace penetrated by rather coarse punctae lying in narrow trenches separated by ridges that curve slightly backward on the posterior half of the carapace and are arcuate toward the front on the anterior part. The surface is studded with pimplelike nodes, instead of ridges, on the posterior one-sixth of the valves.

Hinge line of the right valve curved, following the dorsal margin of the carapace. There is no thickening of the dorsal margin for the teeth. Dorsal margin thin, with terminal taxodont dentitions set like tiny beads. Anterior and posterior dental areas consist of six larger teeth connected by a line of minute rounded teeth. Hinge of the left valve consists of a shallow shelflike groove paralleling the dorsal margin for the reception of the hinge line of the right valve. The anterior socket lies at the anterior end of the shelf, the posterior socket is situated just posterior to it. The hinge consists of anterior and posterior sockets grooved for the reception of the teeth of the right valve. These sockets are connected by a shallow, faintly notched hinge groove. The notches on the connecting groove and of the anterior socket are so weakly developed that they are visible only when the illumination is from a favorable angle. Inner margin of the anterior socket with an upcurling flange. Posterior socket much stronger than the anterior. Radial pore canals straight, threadlike, about fifteen on the anterior end. They

are rather widely spaced in the ventral half of the anterior end and rather closely spaced in the dorsal half. Ventral margin of the valves with a flange slightly posterior to the middle. The calcified portion of the inner lamella extends slightly beyond the inner margin, except along the hinge line, and is broadest at the anterior end of the carapace. Muscle scar pattern of the right valve consists of a vertical row of four closely spaced pyriform scars, with two separated scars vertically beneath these and two oblique scars anterior to the row of four. Muscle scars elongate in the direction of elongation of the valve.

Left valve, syntype, U. I. X—1261, length 0.77 mm, height 0.43 mm; right valve, syntype, U. I. X—1262, length 0.70 mm, height 0.40 mm.

Genus CYTHEROPTERON Sars, 1865

The following discussion of the genus is based on the work of Alexander (1933, pp. 187–190).

The members of this subgenus are distinguished by the wing-like lateral expansions of the shell, which are weakly developed in some species and strongly developed in others. They are but weakly developed in the type species, *C. latissimum*. The general shape is remarkably constant in all members of the genus. The shell, as seen in side view, is ovate in outline.

The dorsal margin is arched, the anterior end rounded, and the posterior end produced to form a short, blunt, narrow, compressed caudal process, which curves more or less strongly upward.

The hinge, in the right valve, consists of two long, narrow, ridgelike multicuspate teeth, one at each end of the hinge line, with corresponding notched depressions or sockets in the left valve. In the latter species, the hinge margin of the left valve, between the terminal sockets, bears a finely serrate or crenulate ridge or bar, which fits into a shallow and obscure notched furrow or groove between the terminal teeth of the right valve. In some Cretaceous forms the bar is weakly developed in the left valve and the corresponding furrow of the right valve is absent, although there is a series of small sockets along the hinge margin between the terminal series of teeth into which the denticles on the bar of the left valve fit.

The muscle scar pattern consists of a vertical row of four small scars located just above the middle of the ventral border and usually a single scar in front of these. The marginal areas are moderately broad with a few, widely spaced radiating pore canals.

Genotype *Cytheropteron latissimum* (Norman)

CYTHEROPTERON MINUTUM
Sutton and Williams, n. sp.
Plate 64, figures 8–10

Carapace minute, in side view subovate. Dorsal margin strongly arched, ventral margin somewhat less so. Anterior and posterior ends evenly rounded and compressed. Carapace tumid. Greatest thickness posterior to the middle. Just above and parallel to the ventral margin the carapace has a strong longitudinal inflation. Greatest height of carapace at middle. Surface of carapace with longitudinal trenches at right angles to the direction of elongation. Between these trenches are narrow, flat ridges. Right valve larger than left.

From inside, the valves are deep. The marginal areas are broad around the anterior and posterior ends. The hinge of the right valve has a line of taxodont crenulations occupying the center half of the dorsal margin and at each end of the hinge is a delicate raised tooth. The hinge of the left valve possesses a line of crenulations and small sockets to receive the teeth of the left valve.

Left valve, syntype, U. I. X—1263, length 0.40 mm, height 0.23 mm; right valve, syntype, U. I. X—1264, length 0.50 mm, height 0.30 mm.

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SOME MIDDLE TERTIARY SMALLER FORAMINIFERA FROM SUBSURFACE BEDS OF JEFFERSON COUNTY, TEXAS[1]

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ABSTRACT—Thirteen new species and two new varieties of smaller foraminifera are described from strata known in the Gulf Coast as the *Discorbis*, *Heterostegina*, and *Marginulina* zones.

THE SUBSURFACE strata commonly known in the Gulf Coast as *Discorbis*, *Heterostegina*, and *Marginulina* zones contain a large fauna of smaller foraminifera. This fauna is related to that of the Vicksburg and to Miocene faunas of Florida, and contains species common to both. The foraminiferal faunas of the Vicksburg and the Florida Miocene largely have been described (see references).

There are also many forms present in the *Discorbis*, *Heterostegina* and *Marginulina* zones which are unknown in the literature. The purpose of this paper is to describe and to illustrate some of the common forms.

All of the species herein described were taken from a core from Stanolind Oil and Gas Company no. B-2 Pipkin, Big Hill prospect, Jefferson County, Texas.

Comparatively few species have been described previously from these beds. A list of the species, including both larger and smaller Foraminifera, follows:

Operculinoides ellisorae Gravelland Hanna
Operculinoides howei Gravell and Hanna
Heterostegina israelskyi Gravell and Hanna
Heterostegina texana Gravell and Hanna
Lepidocyclina colei Gravell and Hanna
Lepidocyclina texana Gravell and Hanna
Bolivina perca Garrett
Marginulina idiomorpha Garrett and Ellis
Marginulina mexicana Cushman var. *vaginata* Garrett and Ellis
Marginulina howei Garrett and Ellis

All species figured in this paper are common and very familiar to economic workers in the Texas-Louisiana Gulf Coast. There are obvious objections to describing new species from subsurface horizons, but the very great stratigraphic importance of the forms herein described, together with their relative abundance and wide distribution seems ample justification for this procedure.

I am indebted to A. D. Ellis, Jr. for much effort in preparing the illustrations. J. A. Cushman kindly provided some types of foraminifera. Henry V. Howe also gave generous assistance.

SYSTEMATIC DESCRIPTIONS

Family TEXTULARIIDAE

Genus TEXTULARIA Defrance

TEXTULARIA MORNHINVEGI Garrett, n. sp.

Plate 65, figures 1a–b, 2

Test large, thick, elongate, tapering, thickest in the central portion, thinning somewhat toward the periphery; periphery rounded; chambers numerous, inner portion of each chamber raised, with a depressed area between the raised portion and the periphery; sutures distinct, except in the early portion, depressed, inclined slightly downward; wall finely arenaceous, fairly smooth; aperture a broadly arched opening at the base of the apertural face.

Specimens from depth of 5,984–5,994 feet

	Length	Width	Thickness
	mm	mm	mm
Syntype 1936	1.04	0.71	0.55
Syntype 1935	1.51	0.79	0.53

Remarks.—Textularia mornhinvegi resembles *T. tumidula* Cushman in having the inner portions of the chambers raised, but is narrower, is not compressed, and has a rounded periphery.

Genus VULVULINA d'Orbigny

VULVULINA IGNAVA Garrett, n. sp.

Plate 65, figures 3a–b, 4, 5

Test elongate, tapering, widest near the apertural end, moderately compressed, thickest along the central portion; periphery

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carinate; chambers distinct, biserial, except for the final chamber, which extends almost across the test; sutures distinct, slightly curved, about flush with surface of test; wall smooth, finely arenaceous; aperture terminal, narrow, elongate.

Specimens from depth of 6,121–6,124 feet

	Length mm	Width mm	Thickness mm
Syntype 1937	1.10	0.65	0.33
Syntype 1938	0.66	0.51	0.24
Syntype 1939	1.14	0.80	0.50

Remarks.—Most specimens of *Vulvulina ignava* do not have the uniserial portion developed and therefore resemble *T. mississippiensis* Cushman. *Vulvulina ignava* is similar to *V. pachycheilus* Hadley, but does not have the strongly oblique sutures, well developed peripheral spines, and off-set uniserial portion. *V. ignava* differs from *V. pectinata* Hantken in being more tapering and in having a distinct keel.

Family LAGENIDAE
Genus ROBULUS Montfort
ROBULUS CHAMBERSI Garrett, n. sp.
Plate 65, figures 8, 9a–b

Test of moderate size, biconvex, close-coiled, with a large boss of very clear material at the umbo; periphery with a fragile, transparent keel; chambers distinct, 5–6 in the final coil; sutures distinct, limbate, of clear material, raised, often very pronounced, curved very sharply at or near the umbo; wall smooth; aperture small, slightly radiate and projecting.

Specimens from depth of 5,647–5,651 feet

	Maximum diameter mm	Thickness mm
Syntype 1940	0.68	0.37
Syntype 1941	0.72	0.41

Remarks.—*Robulus chambersi* is similar to forms which have been referred to *R. clericii* (Fornasini). It differs from them especially in having few chambers, very prominent sutures, and prominent umbones.

ROBULUS LACERTA Garrett, n. sp.
Plate 65, figures 6a–b, 7

Test moderately compressed, with a tendency to uncoil in the later chambers; periphery with a narrow keel, which is usually serrate, composed of clear material; chambers numerous, usually seven to ten in adult specimens; sutures distinct, curved, limbate, formed of clear material, ornamented with lines of raised beads; wall ornamented with beads in the early portion, tending to be smooth in the final chambers; apertural face truncated, with raised edges, especially in young specimens; aperture radiate, with short, tapering neck.

Specimens from depth of 6,034–6,037 feet

	Length mm	Width mm	Thickness mm
Holotype 1942	1.06	0.68	0.35
Paratype 1943	0.70	0.46	0.30

EXPLANATION OF PLATE 65

FIGS. *1a–b, 2—Textularia mornhinvegi* Garrett, n. sp. *1a*, Side view; *1b*, apertural view, syntype no. 1935, ×25. *2*, Side view, syntype no. 1936, ×25. *Heterostegina* zone, middle Tertiary, Texas. (p. 575)

3a–b, 4, 5—Vulvulina ignava Garrett, n. sp. *3a*, Side view; *3b*, apertural view, syntype no. 1937, ×54. *4*, Apertural view, syntype no. 1939, ×54. *5*, Side view, syntype no. 1938, ×52. *Marginulina idiomorpha* zone, middle Tertiary, Texas. (p. 575)

6a–b, 7—Robulus lacerta Garrett, n. sp. *6a*, Side view; *6b*, apertural view, paratype no. 1943, ×67. *7*, Side view, holotype no. 1942, ×55. *Marginulina idiomorpha* zone, middle Tertiary, Texas. (p. 576)

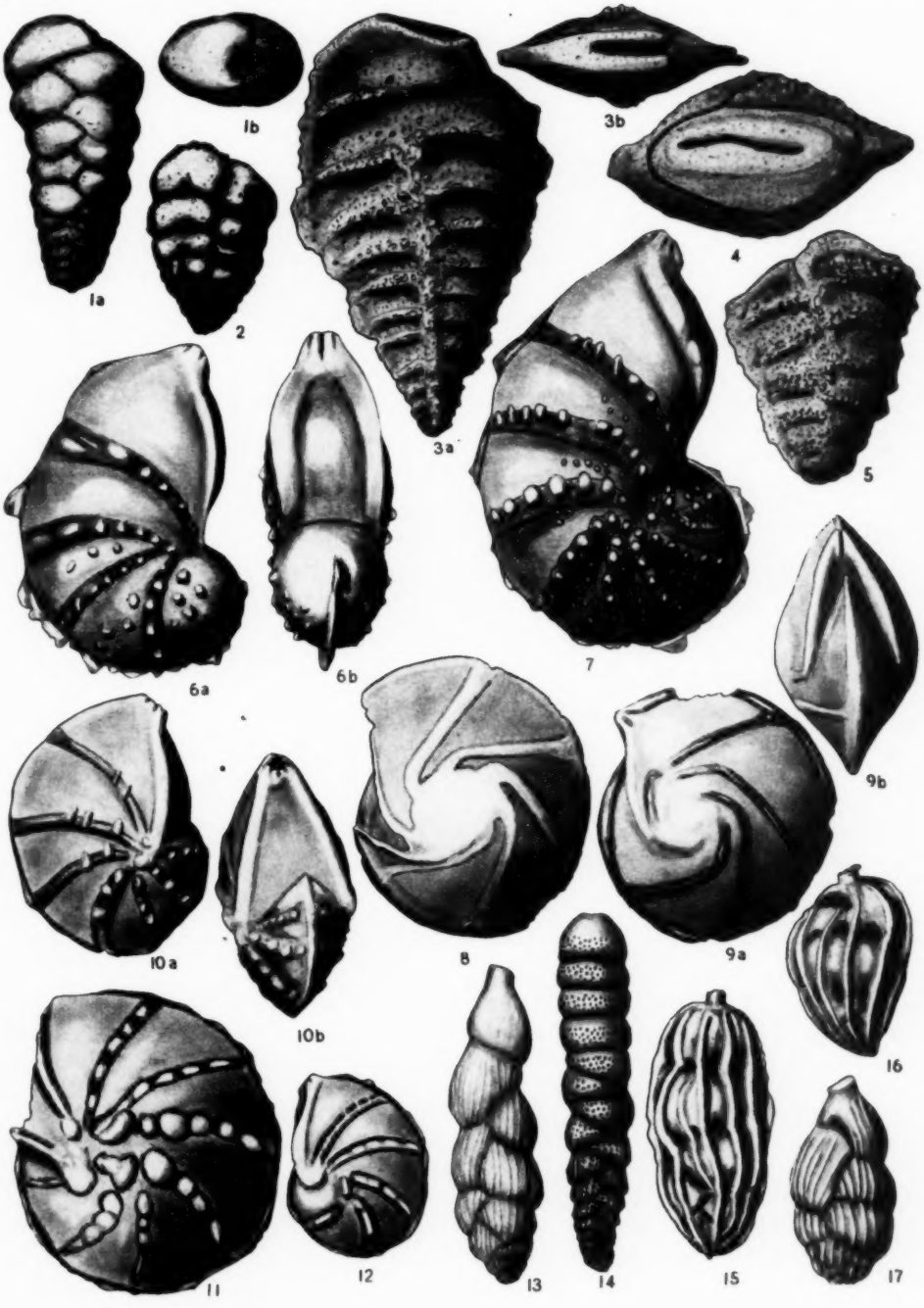
8, 9a–b—Robulus chambersi Garrett, n. sp. *8*, Side view, syntype no. 1941, ×55. *9a*, Side view; *9b*, apertural view, syntype no. 1940, ×54. *Discorbis* zone, middle Tertiary, Texas. (p.576)

10a–b, 11, 12—Lenticulina jeffersonensis Garrett, n. sp. *10a*, Side view; *10b*, apertural view, syntype no. 1945, ×52, young specimen. *11*, Side view, syntype no. 1944, ×54. *12*, Side view, syntype, no. 1946, ×66, young specimen. *Discorbis* zone, middle Tertiary, Texas. (p. 577)

13, 17—Uvigerina howei Garrett, n. sp. *13*, Side view, paratype no. 1949, ×69. *17*, Side view, holotype no. 1948, ×70. *Discorbis* zone, middle Tertiary, Texas. (p. 577)

14—Bifarina vicksburgensis (Cushman) var. *monsouri* Garrett, n. var. Side view, holotype no. 1947, ×70. *Discorbis* zone, middle Tertiary, Texas. (p. 577)

15, 16—Uvigerina israelskyi Garrett, n. sp. *15*, Side view, holotype no 1950, ×54. *16*, Side view, paratype no. 1951, ×50, young specimen. *Heterostegina* zone, middle Tertiary, Texas. (p. 577)



Garrett, Tertiary Foraminifera

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Genus LENTICULINA Lamarck
LENTICULINA JEFFERSONENSIS Garrett, n. sp.
Plate 65, figures 10a–b, 11, 12

Test of moderate size, robust, close-coiled, equally biconvex; periphery with a narrow keel of clear material; chambers distinct, seven to ten in the adult; sutures distinct, curved, limbate, raised, tapering toward the periphery, ornamented with beads; wall smooth, except for the beaded sutures and large nodes in the umbilical area; apertural face truncated, with a raised edge; aperture radiate, with a slight neck.

Specimens from depth of 5,727–5,732 feet

	Maximum diameter	Thickness
Syntype 1944	0.83	0.52
Syntype 1945	0.70	0.35
Syntype 1946	0.40	0.22

Remarks.—*Lenticulina jeffersonensis* resembles *Robulus vaughani* (Cushman), but is less compressed, more tightly coiled, and has more prominently developed sutures.

Family BULIMINIDAE
Genus BIFARINA Parker and Jones
BIFARINA VICKSBURGENSIS (Cushman) var. MONSOURI Garrett, n. var.
Plate 65, figure 14

Test small, elongate, slender, slightly compressed in the initial portion, which is biserial, adult forms having six to ten well developed uniserial chambers; chambers small, numerous, inflated in the uniserial portion; sutures depressed, distinct, inclined in the early portion; wall smooth, with numerous fine perforations; aperture small, terminal, rounded, with a slightly raised lip.

Dimensions of holotype no. 1947, from core at 5,647–5,651 feet: length, 0.71 mm; width, 0.14 mm.

Remarks.—This variety differs from the typical form in being less compressed, and in having a better developed uniserial portion and a less completely developed biserial portion. It apparently represents a more advanced evolutionary stage.

Genus UVIGERINA d'Orbigny
UVIGERINA HOWEI Garrett, n. sp.
Plate 65, figures 13, 17

Test small, elongate, fusiform; periphery slightly lobulate; chambers numerous, inflated; sutures depressed, indistinct; costae numerous, fine, low; in some specimens final chambers are somewhat hispid; aperture small, terminal, with a tapering neck and phialine lip.

Dimensions of holotype no. 1948 from core at 5,647–5,651 feet: length, 0.42 mm; width, 0.21 mm. Dimensions of paratype no. 1949 from core at 5,711–5,714 feet: length, 0.64 mm; width, 0.19 mm.

Remarks.—This small species is often very common in the *Discorbis* zone.

UVIGERINA ISRAELSKYI Garrett, n. sp.
Plate 65, figures 15, 16

Test of moderate size for the genus, elongate, fusiform; chambers indistinct; sutures irregular and deeply depressed; wall ornamented by approximately 10 very distinct, high longitudinal costae of which the majority traverse the entire length of the test; aperture small, terminal, with a short cylindrical neck and phialine lip, which is very fragile, and commonly broken.

Specimens from depth of 5,932–5,935 feet

	Length mm	Width mm
Holotype 1950	0.67	0.32
Paratype 1951	0.52	0.33

Remarks.—*Uvigerina israelskyi* resembles *U. vicksburgensis* Cushman and Ellisor, but differs in the character of its sutures and in having continuous longitudinal costae.

Genus SIPHOGENERINA Schlumberger
SIPHOGENERINA FREDSMITHI Garrett, n. sp.
Plate 66, figure 1

Test small, elongate, slender, tapering in the early portion, uniform in diameter in the later portion; chambers in early portion irregularly triserial, later becoming uniserial, inflated, distinct; sutures distinct, deeply depressed; surface ornamented by fine, low costae, which are broken by the sutures; aperture small, circular, terminal, with a short neck and phialine lip.

Dimensions of holotype no. 1952 from core at 5,711–5,714 feet: length, 0.63 mm; width, 0.18 mm.

Family ROTALIIDAE
Genus DISCORBIS Lamarck
DISCORBIS GRAVELLI Garrett n. sp.
Plate 66, figures 2a–c, 3a–b

Test rather large for the genus, biconvex, dorsal side strongly convex in the later chambers, ventral side moderately convex; periphery moderately acute, lobulate; composed of several whorls, final whorl having six to eight chambers whose size and degree of inflation increase rapidly as added; sutures curved, limbate, composed of clear material; wall smooth, closely covered with fine punctations; aperture on the umbilical side of the periphery, with a slight overhanging lip.

Dimensions of holotype no. 1953 from core at 5,647–5,651 feet: maximum diameter, 0.68 mm; thickness, 0.34 mm. Dimensions of paratype no. 1594 from core at 5,544–5,549 feet: maximum diameter, 0.37 mm; thickness, 0.16 mm.

DISCORBIS NOMADA Garrett, n. sp.
Plate 66, figures 4a–c

Test small, close-coiled, little more than one visible whorl, equally biconvex, ventral umbilicus deeply depressed; periphery evenly rounded, lobulate in the later portion; chambers distinct, inflated, six to seven in the final whorl; sutures distinct, curved, limbate, composed of clear material, raised in the early portion of the test, depressed in the later portion; wall smooth, finely perforate, except for the apertural face; aperture a narrow slit at the base of the apertural face, provided with a slight lip.

Dimensions of holotype no. 1955 from core at 5,544–5,549 feet: maximum diameter, 0.32 mm; thickness, 0.14 mm.

Remarks.—This species has been referred by some writers to *Discorbis* (or *Valvulineria*) *vilardeboana* (d'Orbigny) and to *D. candeiana* (d'Orbigny). The identity of *D. vilardeboana* apparently is in doubt (see Cushman, 1931, p. 34). *D. nomada* differs from the Recent species *D. candeiana* in being equally biconvex, in being finely perforate, and in having little more than one visible whorl. I have not found *D. nomada* to be identical with any figured species from the Florida Miocene.

Genus GYROIDINA d'Orbigny
GYROIDINA VICKSBURGENSIS (Cushman) var.
HANNAI Garrett, n. var.
Plate 66, figures 5a–c

Test small, dorsal side flattened, ventral side strongly convex; chambers inflated, eight to nine in final whorl; periphery broadly rounded, slightly lobulate in final portion; umbilical region on ventral side strongly depressed; sutures distinct, slightly depressed, distinctly curved on the dorsal side, nearly radial on the ventral; wall smooth, polished; aperture an elongate, low arched opening at the base of the apertural face extending from the periphery toward the umbilicus, with a slight lip.

Dimensions of holotype no. 1956 from

EXPLANATION OF PLATE 66

FIGS. *1—Siphogenerina fredsmithi* Garrett, n. sp. Side view, holotype no. 1952, ×67. *Discorbis* zone, middle Tertiary, Texas. (p. 577)

2a–c, 3a–b—Discorbis gravelli Garrett, n. sp. *2a*, Dorsal view; *2b*, ventral view; *2c*, apertural view, holotype no. 1953, ×54. *3a*, ventral view; *3b*, dorsal view, paratype no. 1954 ×66, young specimen. *Discorbis* zone, middle Tertiary, Texas. (p. 578)

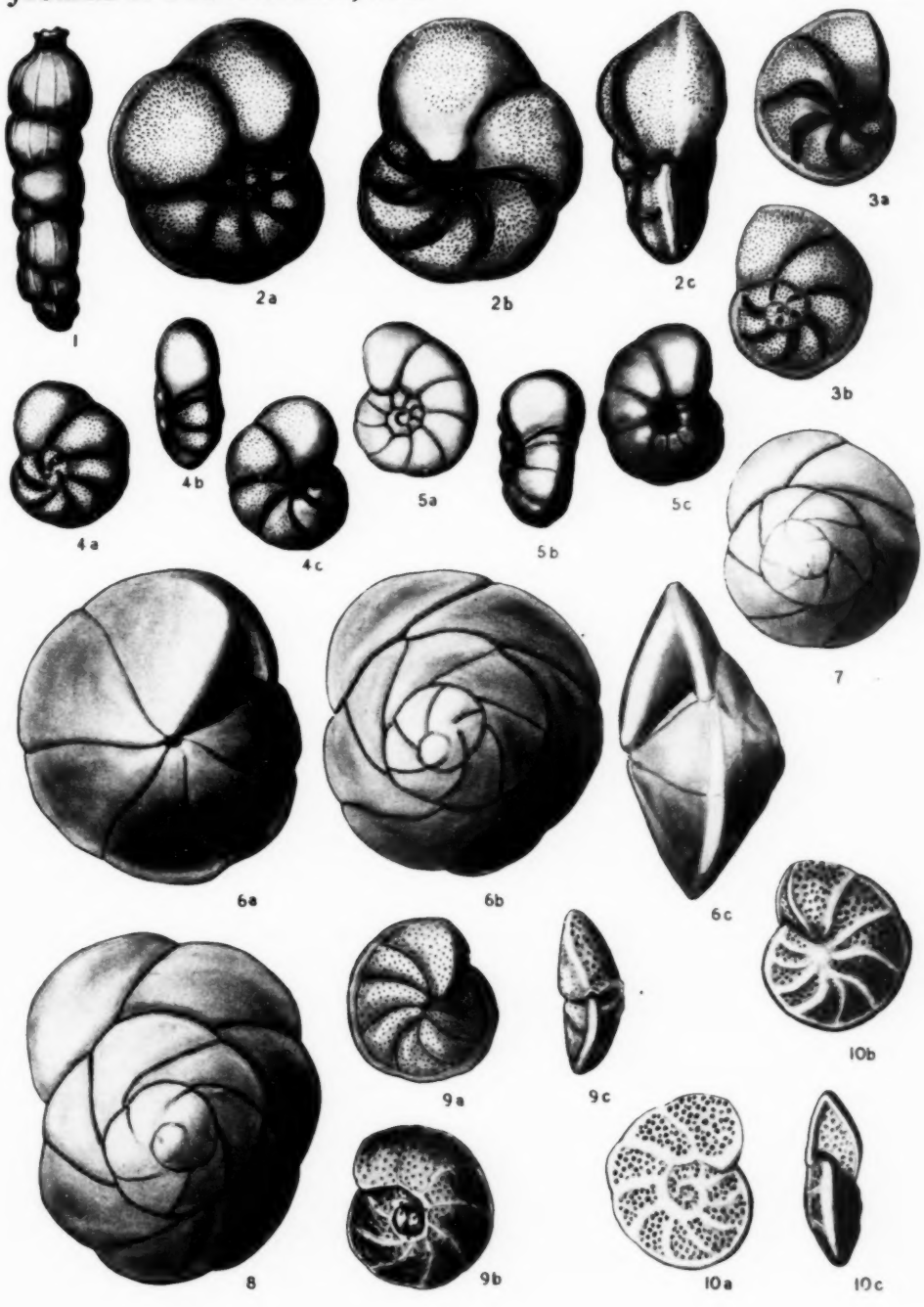
4a–c—Discorbis nomada Garrett, n. sp. *4a*, Dorsal view; *4b*, apertural view; *4c*, ventral view, holotype no. 1955, ×66. *Discorbis* zone, middle Tertiary, Texas. (p. 578)

5a–c—Gyroidina vicksburgensis (Cushman) var. *hannai* Garrett, n. var. *5a*, Dorsal view; *5b*, apertural view; *5c*, ventral view, holotype no. 1956, ×52. *Discorbis* zone, middle Tertiary, Texas. (p. 578)

6a–c, 7, 8—Eponides ellisorae Garrett, n. sp. *6a*, Ventral view; *6b*, dorsal view; *6c*, apertural view, holotype no 1957, ×52. *Marginulina idiomorpha* zone, middle Tertiary, Texas. *7*, Dorsal view, paratype no. 1959, ×54. *Discorbis* zone, middle Tertiray, Texas. *8*, Dorsal view, paratype no. 1958, ×51. *Marginulina idiomorpha* zone, middle Tertiary, Texas. (p. 579)

9a–c—Cibicides moreyi Garrett, n. sp. *9a*, Ventral view; *9b*, dorsal view; *9c*, apertural view, holotype no. 1961, ×70. *Discorbis* zone, middle Tertiary, Texas. (p. 579)

10a–c—Cibicides jeffersonensis Garrett, n. sp. *10a*, Dorsal view; *10b*, ventral view; *10c*, apertural view, holotype no. 1960, ×68. *Discorbis* zone, middle Tertiary, Texas. (p. 579)



Garrett, Tertiary Foraminifera

UNIV. OF MICH.

core at 5,647–5,651 feet: maximum diameter, 0.43 mm; thickness, 0.23 mm.

Remarks.—This variety differs from the typical form in being more compressed.

Genus EPONIDES Montfort

EPONIDES ELLISORAE Garrett, n. sp.

Plate 66, figures 6a–c, 7, 8

Test biconvex, varying in relative convexity of dorsal and ventral sides, dorsal side tending to develop a distinct, polished umbo; periphery subacute, lobulate; chambers numerous, six to eight in final whorl; sutures slightly limbate, dorsal sutures curved, slightly raised, ventral sutures nearly radial, depressed; wall smooth, very finely punctate; aperture an elongate, narrow opening extending from the periphery almost to the umbilicus.

Dimensions of holotype no. 1957 from core at 6,121–6,124 feet: maximum diameter, 0.85 mm; thickness, 0.41 mm. Dimensions of paratype no. 1958 from core at 6,121–6,124 feet: maximum diameter, 0.96 mm; thickness, 0.50 mm. Dimensions of paratype no. 1959 from core at 5,647–5,651 feet: maximum diameter, 0.57 mm; thickness, 0.30 mm.

Remarks.—*Eponides ellisorae* varies considerably in relative convexity of dorsal and ventral sides. The dorsal side is usually moderately convex, at least, but the ventral side may be almost flat. *E. ellisorae* differs from *E. byramensis* (Cushman) in having a less rounded outline, especially at the periphery. *E. ellisorae* is very similar to the recent species *E. antillarum* (d'Orbigny) but is a comparatively wider and more flaring type, has a more distinct dorsal umbo, and has a somewhat different texture.

Family ANOMALINIDAE

Genus CIBICIDES Montfort

CIBICIDES JEFFERSONENSIS Garrett, n. sp.

Plate 66, figures 10a–c

Test small, unequally biconvex, dorsal side slightly convex, ventral side moderately so; periphery subacute; chambers distinct, eight to ten in the final whorl; sutures distinct, curved, limbate, distinctly raised, especially on the dorsal side; wall smooth, coarsely perforate; aperture a low arched opening at the periphery.

Dimensions of holotype no. 1960 from core at 5,727–5,732 feet: maximum diameter, 0.35 mm; thickness, 0.12 mm.

CIBICIDES MOREYI Garrett, n. sp.

Plate 66, figures 9a–c

Test small, unequally biconvex; periphery acute; chambers seven to nine in the final whorl; periphery slightly twisted in some cases; sutures fine, distinct, raised on dorsal side, depressed on ventral; umbilical region on dorsal side filled with an irregular mass of shell material; surface of dorsal side rough, with perforations of moderate size, ventral side smooth, finely perforate; aperture peripheral.

Dimensions of holotype no. 1961 from core at 5,403–5,406 feet: maximum diameter, 0.33 mm; thickness, 0.12 mm.

Remarks.—*Cibicides moreyi* is similar to *C. pseudoungerianus* (Cushman), but is smaller, more finely perforate, and less lobulate.

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SOME OSTRACODA OF THE GENUS *CYTHEREIS* FROM THE COOK MOUNTAIN EOCENE OF LOUISIANA

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ABSTRACT—A short history of the genus *Cythereis* is given. Ten species belonging to the genus *Cythereis* are described and illustrated. Eight of the species are new, two have been previously described, one of these under *Cythere*. A list of localities examined and a check list showing the occurrence of the species described are included.

THE PURPOSE of this paper is to describe those species of the genus *Cythereis* from the Cook Mountain Eocene of Louisiana which are characterized by a smooth or reticulate surface and which bear prominent ventral and dorsal ridges. It is the belief of the writer that this type of *Cythereis*, as distinguished from the more varied spinose species, will be very useful in surface and subsurface zonation.

Very little has been written of the Ostracode fauna of any of the formations of the Claiborne group. Murray (1938) has described forms of *Loxoconcha*, and Martin (1939) species of the genus *Cytheropteron*. Maria M. Stadnichenko (1927) in her work on the marine Yegua of East Texas figured and described 12 species of Ostracoda. Only two of these species, described as *Cythereis leeana* and *Cythereis bursilloides*, fall within the scope of this paper.

Jones (1849), one of the early workers on fossil species, described *Cythereis* as a subgenus of *Cythere*. Regarding the surface ornamentation, Jones (p. 15) remarked:

> On the valves three eminences or tubercles are more or less strongly developed; one rather anterior to the center, which is very characteristic of this section, . . . , and one at each angle formed by the junction of the posterior with the superior and inferior borders. From each of these last mentioned tubercles a ridge generally arises, which is continued more or less uninterruptedly around the edge of the valve.

From this description, it is apparent that the species included in this writing agree with *Cythereis*, as described by Jones, in surface sculpture. The species also agree in other respects with essential characters of *Cythereis*.

Other species of *Cythereis* from the Cook Mountain will be described in a subsequent paper.

Described Tertiary species of *Cythereis* characterized by dorsal and ventral ridges are:

Vicksburg group, Oligocene
- *Cythereis blanpiedi* Howe, 1936
- *Cythereis blanpiedi* Howe var. *melvinensis* Howe, 1936
- *Cythereis chawneri* Howe and Law, 1936
- *Cythereis kempi* Howe and Law, 1936
- *Cythereis weaveri* Howe and Law, 1936

Jackson group, Eocene
- *Cythereis broussardi* Howe and Chambers, 1935
- *Cythereis hysonensis* Howe and Chambers, 1935
- *Cythereis hysonensis* Howe and Chambers var. *dohmi* Howe and Chambers, 1935

Claiborne group, Eocene
- *Cythereis leeana* (Stadnichenko), 1927
- *Cythereis bursilloides* Stadnichenko, 1927

Midway formation, Eocene
- *Cythereis cancellosa* Alexander, 1934
- *Cythereis sculptillis* Alexander, 1934
- *Cythereis prestwichiana* Jones and Sherborn, 1887
- *Cythereis midwayensis* Alexander, 1934

The writer wishes to thank John Huner, Justin Rukas, and Dr. R. Dana Russell for the use of samples collected while engaged in research on areas in Louisiana, and Dr. Henry V. Howe, director of the Louisiana Geological Survey for his valuable assistance and the use of his type collection. The writer also wishes to thank S. M. McDonald for his kind suggestions on the illustrations.

All type specimens are deposited in the Henry V. Howe Collection, School of Geology, Louisiana State University.

SYSTEMATIC DESCRIPTIONS

Order OSTRACODA Latreille
Suborder PODOCOPA Sars
Family CYTHERIDAE Baird, 1850
Genus CYTHEREIS Jones, 1849

Carapace in side view highest at anterior cardinal angle, longest through or below middle. Dorsal and ventral margins straight, or nearly so, converging gently toward the posterior. Anterior rounded, denticulate, usually with raised rim, often oblique. Posterior compressed, rounded, or angulate, usually bearing prominent spines.

Surface variously ornamented, usually with distinct swelling located near the middle.

Viewed from inside, hinge of the right valve consists of a strong, pointed anterior tooth and postjacent socket, a long narrow groove which parallels the dorsal margin; and a posterior tooth. Hinge of the left valve consists of an ovate anterior socket, behind which is a high blunt tooth, the long sharp dorsal margin which serves as a bar and above which is usually a faint groove; and a posterior socket. Marginal area broad or narrow. Line of concresence and inner margin usually coinciding. Marginal pore canals rather numerous. Muscle scar area usually obscured by ornamentation.

Viewed from above, generally thickest through central swelling. Eyespots usually distinct. Left valve larger than right and overlapping the right valve at anterior and posterior cardinal angles.

Discussion.—Jones (1849), when establishing *Cythereis* as a subgenus did not select a subgenotype, although, following his original description, he described the following species, in order: *Cythereis interrupta* (Bosquet), and several varieties, *Cythereis gaultina*, new; *Cythereis macrophthalma* (Bosquet); *Cythereis triplicata* (Roemer); *Cythereis quadrilatera* (Roemer); *Cythereis ciliata* (Reuss); *Cythereis lonsdaleiana*, new; *Cythereis cornuta* (Roemer); *Cythereis alata* (Bosquet).

Alexander (1933) selected *Cythereis ornatissma* (Reuss), a synonym of *Cythereis ciliata* (Reuss), as being most typical of the genus, yet Alexander's illustrations do not agree with those by Jones of *Cythereis ciliata*, as in Jones' illustrations of this species, the dorsal and ventral ridges are very prominent.

Thus, it would seem that to limit accurately the genus *Cythereis*, the original specimens of Jones must be examined and studied, and from them the genotype selected in order that the true generic characteristics be known.

CYTHEREIS CLAIBORNENSIS
Gooch, n. sp.
Plate 67, figures 5, 6, 10

Carapace in side view oblong-quadrate, highest at the anterior cardinal angle. Dorsal margin nearly straight, except just behind the anterior cardinal angle, where it is strongly curved and parallels the straight ventral margin. Anterior broadly rounded, thick. Posterior compressed, irregularly angulate, thickened, with several blunt spines.

Surface irregularly reticulate, bearing a prominent swelling a short distance in front of the center, from which three fairly prominent ridges extend anteriorly. Main ridge prominent, begins at anteroventral angle, extends backward to a point about one-third the length of the carapace from the posterior, forms a high point, continues toward the dorsal margin, where it is interrupted and forms a sharp angle, then continues along the dorsal margin to a point just below and behind the eyespot. Another fairly prominent ridge extends from the central swelling toward the posterior and joins the main ridge near the center of the carapace.

Viewed from above, thickest at the central swelling. Eyespots rather small, distinct.

Internally, valves rather deep, marginal area rather broad. Line of concresence lies just inside of and parallel to the inner margin. Marginal pore canals straight, numerous, about 26 on anterior, none on posterior. Hinge of right valve consists of a strong, pointed anterior tooth, a subtriangular socket, which opens into a long narrow groove paralleling the dorsal margin, and a long, blunt posterior tooth. Hinge of left valve consists of an anterior socket behind which is a high, blunt tooth, a long sharp bar above which is a faint groove, and a somewhat oblong posterior

socket. Muscle scar area obscured by ornamentation.

Dimensions of a complete carapace, holotype, slide no. 2100, from locality no. 4: length, 0.58 mm, height, 0.33 mm, thickness, 0.30 mm.

Remarks.—Members of this species are well represented by moults. For the purpose of simplification, the author has illustrated what he considers a very young stage, although moults may be observed in every stage from the very young through to the adult.

CYTHEREIS HOWEI
Gooch, n. sp.
Plate 67, figures 15, 16

Carapace in side view angular-pyriform, much compressed. Dorsal and ventral margins straight, converging slightly toward the posterior. Anterior end broadly rounded, bearing a high, rounded ridge. Posterior end compressed, angular, coming to a distinct point in the middle, with a thickened rim and several small nodes.

Surface strongly but regularly reticulate, pits almost hexagonal. Central swelling fairly prominent. A second swelling is located centrally and a little over one-third the length of the carapace in front of the posterior end. Two prominent ridges present; one beginning at the anterior cardinal angle extends around the anterior end and parallel to the anterior margin to a point behind the anteroventral angle, thence up and backward to a high terminating point a short distance behind the posterior central swelling and near the ventral margin. The other ridge starts just opposite the terminating point of the first and a short distance behind the posterior central swelling, extends to the dorsal margin and then sinuously parallel to the dorsal margin to a point a short distance behind and below the anterior cardinal angle.

Viewed from above, carapace thin, thickest through anterior central swelling. Eyespots indistinct. Anterior rather thick, posterior thin.

Viewed from inside, valves shallow. Marginal area rather broad. Inner margin and line of concrescence coincide throughout. About 12 marginal pore canals on the anterior, about five on the posterior. Hinge in the right valve consists of a pointed anterior tooth, an oblong socket, a narrow groove paralleling the dorsal margin, and a slightly oblong posterior tooth. Hinge of the left valve consists of an anterior socket, a pointed tooth, a straight, sharp bar above which is a faint groove, and an oblong posterior socket. The hinge of this species typically is set well back toward the posterior. Muscle scar area obscured by ornamentation.

Dimensions of a complete carapace, holotype slide no. 2104, from locality no. 3: length, 0.56 mm, height, 0.31 mm, thickness, 0.23 mm.

Remarks.—Characteristics of this very distinctive species are the compressed carapace, the heavy reticulations and ridges, the peculiar hinge, and the pointed posterior. Named in honor of Dr. Henry V. Howe, director, Louisiana Geological Survey.

CYTHEREIS WINNIANA
Gooch, n. sp.
Plate 67, figures 4, 9

Carapace in side view oblong-quadrate, highest at anterior cardinal angle. Dorsal and ventral margins nearly straight, converging slightly toward the posterior. Anterior broadly and slightly obliquely rounded, bearing a rim which drops off sharply toward the anterior and slopes gradually toward the posterior. Posterior end compressed, angulate, bearing a raised rim with several prominent spines located below the middle, small spines frequently present above the middle.

Surface of carapace polished, nearly smooth. Central swelling rounded, located just in front of center. Ridge prominent, beginning just behind anteroventral angle, continuing posteriorly just above and parallel to the ventral margin to a point about one-third the length of the carapace from the posterior end, there reaching its greatest height in a distinct point, thence extending posterodorsally across the shell at about 120° angle to the dorsal margin, then extending along the dorsal margin, curving downward and ending just behind and below the eyespot. Distinct pits located just inside the ridge on dorsal and ventral

sides. Small nodes irregularly distributed over the carapace.

Viewed from above, widest behind the middle at the high point of ventral ridge. Eyespots prominent, small.

Viewed from the inside, marginal area rather narrow, line of concresence and inner margin coinciding. Marginal pore canals numerous, about 25, closely spaced on the anterior, about 14, widely spaced on the posterior. Hinge of right valve consists of a thick, pointed anterior tooth, a deep, triangular socket, a long, narrow groove paralleling the dorsal margin, and a blunt, slightly oblong posterior tooth. Hinge of left valve consists of a deep anterior socket, behind that a pointed tooth, a straight, sharp bar above which is a faint groove, and a slightly oblong posterior socket. Muscle scar area circular, located in the high central swelling.

Dimensions of a complete carapace, holotype, slide no. 2107, from locality no. 4: length, 0.56 mm, height, 0.28 mm, thickness, 0.29 mm.

Remarks.—This species is characterized by the nearly smooth, polished surface and distinctive outline.

CYTHEREIS LEEANA (Stadnichenko)
Plate 67, figure 14

Cythere leeana STADNICHENKO, *1927*, Jour. Paleontology, vol. 1, no. 3, p. 236, pl. 39, fig. 26.

Carapace in side view angular-pyriform, highest at the anterior cardinal angle. Dorsal margin nearly straight, ventral margin slightly convex. Anterior broadly rounded, slightly oblique, bears a thickened rim and several blunt spines. Posterior angulate, rimmed.

Surface of carapace smooth, polished. Highest just in rear of central swelling. Normal pore canals large, conspicuous, widely scattered. Dorsal ridge begins behind and below eyespot, extends to and overlaps dorsal margin and continues to posterior cardinal angle. Ventral ridge begins near anteroventral angle, extends along the dorsal margin to a point less than one-third the length of the carapace from the posterior end where it rises to a blunt point and ends abruptly downward. On the dorsal side of the ventral ridge are located about six large pits, which continue around and behind anterior rim. Below the ventral ridge is located another short, thickened ridge which overlaps the ventral margin.

Viewed from above, thickest through center and at ventral ridge point. Eyespots large, distinct.

Viewed from inside, valves deep. Inner margin and line of concresence coincide throughout. Marginal area narrow. Marginal pore canals numerous, about 32 on anterior, about 12 on the posterior margin. Hinge strong, in right valve consists of a large, strong, pointed anterior tooth, behind that a deep oblong socket which leads into a long narrow groove paralleling the dorsal margin, and a large blunt somewhat oblong, posterior tooth. Hinge of left valve consists of a deep oval anterior socket, behind that a pointed tooth, a long raised bar above which is a faint groove, and a deep oblong, posterior socket.

Dimensions of a complete carapace, topotype, slide no. 2110, from locality no. 10: length, 0.63 mm, height, 0.38 mm, thickness, 0.34 mm.

Remarks.—*Cythereis leeana* is practically identical with *Cythereis bursilloides*, except that *Cythereis leeana* is smooth or partly so, and *Cythereis bursilloides* is coarsely reticulate.

CYTHEREIS BURSILLOIDES
Stadnichenko
Plate 67, figures 12, 13

Cythereis bursilloides STADNICHENKO, *1927*, Jour. Paleontology, vol. 1, no. 3, pp. 239–240, pl. 39, figs. 21–23.

Although the original description was detailed, the illustration was not sufficiently distinct. For this reason a topotype specimen is herein illustrated on a slightly larger scale than other figures.

Dimensions of a complete carapace, topotype, slide no. 2113, from locality no. 10: length, 0.69 mm, height, 0.41 mm, thickness, 0.39 mm.

CYTHEREIS UNDOSA
Gooch, n. sp.
Plate 67, figures 17, 18

Carapace in side view elongate-ovate, highest at the anterior cardinal angle. Dorsal margin sinuous, ventral margin nearly straight, both converging slightly toward

the posterior. Anterior end broadly rounded, bearing a few small, blunt spines, and completely encircled by a high narrow rim. Posterior margin angular, with a rim and a few small nodes.

Surface of carapace smooth and polished, with slight swelling just below and in front of the center. From just in front of the posterior cardinal angle, a low ridge extends sinuously along and below the dorsal margin to a point just behind the eyespot. Another pronounced ridge begins at a point about one-third the length of the carapace in front of the posterior end and extends forward and downward to a point near the end of the anterior rim.

Viewed from above, the carapace is much compressed, widest at the central swelling. Eyespots indistinct.

Viewed from inside the valves are shallow. Marginal area broad below the middle of the anterior end, narrow above. Marginal pore canals apparently few, though indistinct. Hinge rather heavy, consisting in the right valve of a large pointed anterior tooth, behind which is a deep socket. At the posterior cardinal angle is a large pointed tooth. The straight, narrow dorsal margin bears a narrow groove. Left valve consists of an anterior socket behind which is a large pointed tooth, a straight, narrow bar above which is a faint groove, and an oval posterior socket.

Dimensions of a complete carapace, holotype no. 2116, from locality no. 4: length, 0.50 mm, height, 0.24 mm, thickness, 0.17 mm.

Characteristics.—This species is very similar to *Cythereis broussardi* from the Jackson Eocene, but may be distinguished from *C. broussardi* by its smaller size, more delicate carapace, and lack of surface ornamentation.

Cythereis couleycreekensis
Gooch, n. sp.
Plate 67, figures 1, 2, 3, 8

Carapace in side view oblong-quadrate, highest on anterior through eyespot. Dorsal and ventral margins nearly straight, converging slightly toward the posterior. Anterior end broadly rounded, thick, bearing several thick, short, blunt spines. Posterior end compressed, rounded, thick, with three spines located below the middle.

Surface of carapace bears numerous irregular pits and ridges. The surface also bears a slight swelling just anterior to the center from which a prominent ridge extends to the rear and upwards almost to the posterodorsal angle and thence along the dorsal margin anteriorly until fading near the anterodorsal angle. Another prominent ridge begins just behind and below the central swelling, extending downward and anteriorly to the anteroventral angle and thence along the anterior angle to the eyespot. Another large raised portion is

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Explanation of Plate 67

Figs. *1, 2, 3, 8—Cythereis couleycreekensis* Gooch, n. sp. *1*, Lateral view of left valve, ×57. *2*, Interior view of right valve, ×57. *3*, Interior view of left valve, ×57. *8*, Dorsal outline of complete specimen, ×57. (p. 584)

4, 9—Cythereis winniana Gooch, n. sp. *4*, Lateral view of left valve, ×57. *9*, Dorsal outline of complete specimen, ×57. (p. 582)

5, 6, 10—Cythereis claibornensis Gooch, n. sp. *5*, Lateral view of left valve of adult, ×55. *6*, Lateral view of left valve of moult, ×55. *10*, Dorsal outline of complete specimen of adult ×55. (p. 581)

7, 11—Cythereis milamensis Gooch, n. sp. *7*, Lateral view of left valve, ×55. *11*, Dorsal outline of complete specimen, ×55. (p. 585)

12, 13—Cythereis bursilloides Stadnichenko. *12*, Lateral view of left valve of adult, ×57. *13*, Dorsal outline of complete specimen, ×57. (p. 583)

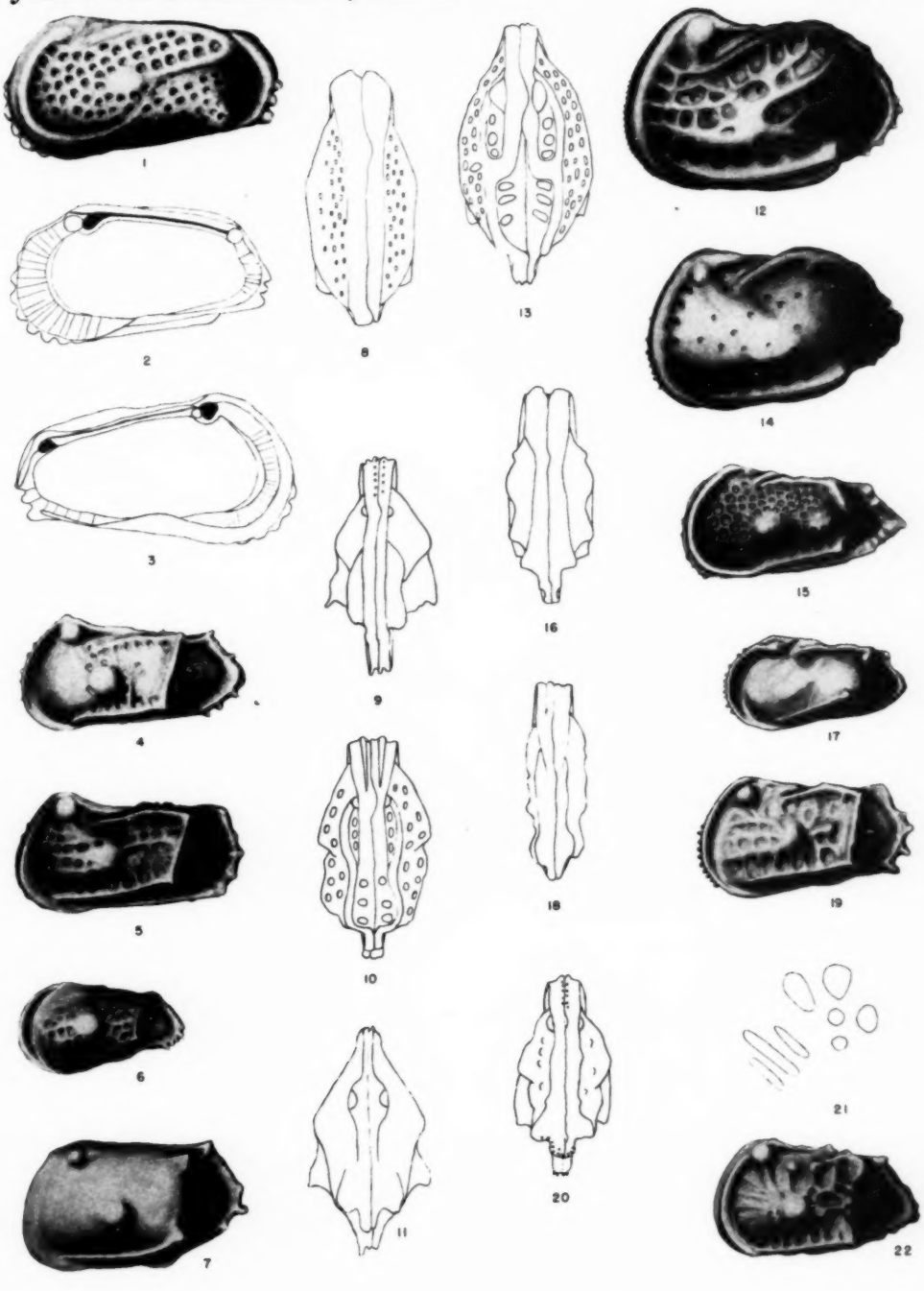
14—Cythereis leeana (Stadnichenko). Lateral view of left valve, ×60. (p. 583)

15, 16—Cythereis howei Gooch, n. sp. *15*, Lateral view of left valve, ×57. *16*, Dorsal outline of complete specimen, ×57. (p. 582)

17, 18—Cythereis undosa Gooch, n. sp. *17*, Lateral view of left valve, ×52. *18*, Dorsal outline of complete specimen, ×52. (p. 583)

19—Cythereis collei Gooch, n. sp. Lateral view of left valve, ×55. (p. 585)

20, 21, 22—Cythereis rukasi Gooch, n. sp. *20*, Dorsal outline of complete specimen, ×57. *21*, Muscle scar pattern of left valve, ×165. *22*, Lateral view of left valve, ×57. (p. 586)



Gooch, Eocene Ostracoda

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present just in front of the posteroventral angle.

Viewed from above, the carapace is compressed, thickest at central swelling and behind the middle at the posteroventral swelling. Anterior very thick, about one-half thickness of central swelling. Eyespots small and indistinct.

Viewed from the inside, valves rather thick. Inner margin and line of concrescence coincide on posterior. On the anterior the line of concrescence lies just within and parallel to the inner margin. Marginal pore canals numerous anteriorly, about 20 to 22, few posteriorly, about five to seven. The hinge is heavy, consisting in the right valve of a large anterior tooth, behind which is a deep triangular socket. At the posterior end of the hinge is a large tooth, and connecting the anterior socket and posterior tooth is a small groove which parallels the dorsal margin. Hinge of left valve consists of a deep oval anterior socket, behind that a rounded tooth, a long bar above which is a long, narrow groove, and a posterior oval socket. Muscle scar area obscured by ornamentation.

Dimensions of a complete carapace, holotype, slide no. 2119, from locality no. 2: length, 0.68 mm, height, 0.38 mm, thickness, 0.28 mm.

Remarks.—This distinctive species is characterized by the rounded carapace, distinctive outline, rounded, inconspicuous ridges and the three spines located below the middle of the posterior end.

CYTHEREIS MILAMENSIS
Gooch, n. sp.
Plate 67, figures 7, 11

Carapace, in side view, oblong-quadrate, highest at the anterior cardinal angle. Dorsal margin straight, except at the posterior cardinal angle where it rises to a distinct point. Ventral margin convex. Anterior end broadly rounded, slightly oblique, without a rim. Posterior end slightly angulate, thickened, with several conspicuous spines.

Surface of carapace smooth, except for the gentle central swelling located below and in front of the middle, and for the ventral ridge, which begins near the anteroventral angle and extends along the dorsal margin to a point about one-third the length of the carapace from the posterior end where it rises to a prominent, blunt point. Below and in front of the posterior cardinal angle is a sharp, distinct node.

Viewed from above, central swelling prominent, thickest through ventral ridge points. Eyespots large, distinct. Anterior end sharply tapering.

Internally, marginal area rather narrow. Inner margin and line of concrescence coincide throughout. About 28 straight pore canals on anterior margin and about 11 on posterior margin, where they are often grouped in threes and twos. Hinge of right valve consists of a long, pointed anterior tooth, behind that a deep oval socket leading into a long, narrow groove, above which is a very faint groove. A small bar separates the two grooves. At the posterior end of the hinge line is an oblong tooth. Hinge of the left valve consists of an oval anterior socket, behind that a small, pointed tooth, a long bar, and an oblong posterior socket. Between the bar and the dorsal margin is a long depressed area which probably corresponds to a groove.

Dimensions of a complete carapace, holotype, slide no. 2123, from locality no. 1: length, 0.57 mm, height, 0.33 mm, thickness, 0.32 mm.

Remarks.—This species is characterized by its short, rounded outline, by the smooth surface, and very short dorsal ridge.

CYTHEREIS COLLEI
Gooch, n. sp.
Plate 67, figure 19

Carapace in side view oblong-quadrate, highest at anterior cardinal angle. Dorsal and ventral margins nearly straight, slightly sinuous. Anterior broadly rounded, denticulate, with rim which slopes gradually toward the posterior extremity, sharply toward the anterior end. Posterior margin angulate, with thickened rim and several conspicuous spines.

Surface of carapace coarsely reticulate. From the prominent central swelling, three ridges extend toward the anterior margin. Main ridge prominent, begins near anteroventral angle, parallels ventral margin to a point about one-third length of the carapace from the posterior end where it bends sharply and rises to a point, continues to-

ward the dorsal margin where it again bends abruptly toward the anterior, follows the dorsal margin for a short distance, then curves downward to a point below and behind the eyespot.

Viewed from above, almost identical in form to *Cythereis winniana*, thickest through point on ventral ridge. Eyespots small, distinct.

Viewed from inside, deeply concave, marginal area rather narrow. Marginal pore canals numerous, straight, often in pairs, about 27 on the anterior, about 13 on the posterior. Line of concresence and inner margin coincide throughout. Hinge strong, in the right valve consists of a thick, pointed posterior tooth, behind that a deep, triangular socket, a narrow groove parallel to the dorsal margin, and a slightly oblong posterior tooth. Hinge of the left valve consists of a deep, oval, anterior socket, behind that a pointed tooth, a long, sharp bar above which is a narrow groove, and an oblong posterior socket. Muscle scar area obscured by ornamentation.

Dimensions of a left valve, syntype no. 2126, from locality no. 1: length, 0.57 mm, height, 0.32 mm.

Remarks.—This species is very similar to *Cythereis winniana* in outline, but differs in surface sculpture. *Cythereis winniana* is smooth, or nearly so, while *Cythereis collei* is coarsely reticulate. Named in honor of Jack Colle, geologist, Houston, Texas.

Cythereis rukasi
Gooch, n. sp.
Plate 67, figures 20, 21, 22

Carapace oblong-quadrate in lateral view, highest at the anterior cardinal angle. Anterior end broadly rounded and bearing a rim, posterior end angular, pointed below the center, with thickened rim and several blunt spines. Dorsal and ventral margins straight, converging gently toward the posterior.

Surface of carapace coarsely ornamented with irregular pits and ridges. Central swelling prominent. A prominent alate process parallels the ventral margin, beginning near the anteroventral angle and terminating in a high point about one-third the length of the carapace from the posterior end. On the dorsal margin opposite this point is another prominent though somewhat blunt point.

Viewed from above the carapace is thickest through the alate projections behind the middle. Eyespots distinct.

Viewed internally the valves are rather deep. Line of concresence and inner margin coincide throughout. Marginal area rather narrow. Marginal pore canals numerous, about 28 on the anterior, about 12 on the posterior. Hinge of the right valve consists of a blunt anterior tooth, behind that a deep oval socket leading into a long, narrow groove which parallels the dorsal margin, and a somewhat oblong posterior tooth. Hinge of left valve consists of an anterior socket, behind that a pointed tooth, a long narrow bar above which is a faint groove and an oblong posterior socket. Muscle scar area circular, located in central swelling and consisting of four somewhat ovate scars arranged in a circle with a smaller scar in the middle, and below and behind these, three elongate parallel scars.

Dimensions of a complete carapace, holotype slide no. 2128, from locality no. 1: length, 0.51 mm, height, 0.31 mm, thickness, 0.25 mm.

Remarks.—Named in honor of Justin M. Rukas, assistant geologist, Louisiana Geological Survey.

Localities

(1) J. H. 71—Cook Mountain formation—Along C.C.C. road north of Couley between La. 480 and La. 9 in ditch on SW side of road, about ⅛ mile SE of Range Creek, SE ¼, SE ¼, SE ¼, sec. 26, T. 11 N., R. 5 W., Winn Parish, La.

(2) JH 62—Cook Mountain formation—In ditch on NE side of Emergency Conservation Works Road No. 21 on slope leading down to Couley Creek, SE ¼, NE ¼, NE ¼, sec. 22, T. 10 N., R. 2 W., 18 inches above base of slope, Winn Parish, La.

(3) JH 99—Cook Mountain formation—Along C.C.C. tramline road, about 2½ miles west of Calvin, from Creek branch crossing road, SE ¼, NW ¼, SE ¼, sec. 7, T. 11 N., R. 4 W., Winn Parish, La.

(4) JH 111—Cook Mountain formation—Ditch leading to creek on south side of lower Dodson road, upper 2 feet of 12 foot bed, NE¼, SW ¼, SW ¼, sec. 28, T. 13 N., R. 3 W., Winn Parish, La. "Operculina zone" of Cook Mountain.

(5) JH 96—Cook Mountain formation—Road cut SE side of La. Highway 6 at the intersection of La. 6 and St. Maurice road, NW ¼, NW ¼, SE ¼, NE ¼, sec. 20, T. 10 N., R. 5 W., Winn Parish, La.

DISTRIBUTION OF SPECIES IN COOK MOUNTAIN FORMATION

Localities	*Cythereis coudeycreekensis*	*Cythereis winniana*	*Cythereis undosa*	*Cythereis milamensis*	*Cythereis rukasi*	*Cythereis claibornensis*	*Cythereis bursilloides*	*Cythereis keeana*	*Cythereis collei*	*Cythereis howei*
1.....	—	x	x	x	x	x	—	—	x	—
2.....	x	x	x	—	—	—	x	—	—	—
3.....	—	x	—	—	—	x	—	—	—	x
4.....	—	x	x	—	—	x	—	—	—	x
5.....	—	x	x	—	—	x	—	—	x	—
6.....	x	—	x	—	—	—	—	—	—	—
7.....	x	—	—	—	—	—	—	—	—	—
8.....	x	—	x	—	—	—	—	—	—	—
9.....	—	—	—	—	—	—	x	x	—	—
10.....	x	—	—	—	—	—	x	x	—	—
11.....	x	x	—	—	—	x	—	—	x	—
12.....	—	x	—	—	—	x	—	—	x	—
13.....	x	x	—	—	—	x	—	—	x	—
14.....	—	x	x	—	x	x	—	—	x	—
15.....	—	x	—	—	—	x	—	—	x	—
16.....	—	x	—	—	—	x	—	—	x	—
17.....	—	x	x	—	x	x	—	—	x	—
18.....	—	x	x	—	x	x	—	—	x	x
19.....	—	x	x	—	—	x	—	—	—	x
20.....	—	—	—	—	x	x	—	—	—	—
21.....	—	x	—	—	x	—	—	—	—	x

(6) M. Roberts loc. 2—On the left bank of Saline Bayou beneath the L. & A. Railroad bridge at St. Maurice, sec. 15, T. 9 N., R. 6 W., Winn Parish, La.—Bed 2.
(7) M. Roberts loc. 3—As above, Bed 3.
(8) M. Roberts loc. 4—As above, Bed 4.
(9) HVH Loc. 240, Renick and Stenzel loc. 4, U. of Tex. Bull. 3101. 200 Yds. above old County road bridge on Highway 21, Little Brazos River, Brazos Co., Texas.
(10) Stadnichenko loc. 2—Cook Mountain formation. Evergreen Crossing, Elm Creek, 5 miles north of Giddings, Lee Bounty, Texas. A. D. Ellis, Jr., Collector.
(11) RU 207—Book Mountain formation—Road cut on east side along State road #39, 2.3 miles south of Provencal, in the SW ¼, NW ¼, NE ¼, sec. 4, T. 7 N., R. 8 W., Natchitoches Parish, La.
(12) RU 238—Cook Mountain formation—Road cut on west side along Flora-Old River road, 0.8 miles south of the new Old River bridge in the SW ¼, SE ¼, SE ¼, regular sec. 9, T. 8 N., R. 7 W., Natchitoches Parish, La.
(13) RU 274 F—Cook Mountain formation—Along creek bank about 500 feet east and downstream from bridge on the Flora-Old River road, in the SE ¼, NW ¼, SE ¼, sec. 16, T. 8 N., R. 7 W., Natchitoches Parish, La.
(14) JH 36—Cook Mountain formation—Ditch along La. 6, up from Creek on NW side of road, in SW ¼, NE ¼, SE ¼, NE ¼, sec. 16, T. 10 N., R. 5 W., Winn Parish, La.
(15) JH 39—Cook Mountain formation—Field one-fourth south of La. highway, SE ¼, NE ¼, NW ¼, sec. 8, T. 11 N., R. 4 W., Winn Parish, La.
(16) JH 50—Cook Mountain formation—Ditch on west side of La. 480, about ½ mile south of Calvin, in NE ¼, NW ¼, NE ¼, sec. 9, T. 11 N., R. 4 W., Winn Parish, La.
(17) JH 59—Cook Mountain formation—Along logging road southeast from Emergency Conservation Works road, in SW ¼, NE ¼, SW ¼, sec. 15, T. 10 N., R. 5 W., Winn Parish, La.
(18) JH 82—Cook Mountain formation—Ditch about 100 yds. north of the forestry building at C.C.C. camp on La. 480, NE ¼, SE ¼, sec. 33, T. 11 N., R. 4 W., Winn Parish, La.
(19) JH 113—Cook Mountain formation—Ditch leading to Creek branch on south side of lower Dodson road, NE ¼, SW ¼, sec. 28, T. 13 N., R. 3 W., Winn Parish, La.
(20) JH 212—Cook Mountain formation—Auger hole 10 feet west of La. 5, in SE corner NW ¼, NW ¼, SE ¼, sec. 5, T. 13 N., R. 3 W., Winn Parish, La. Depth, 17½ feet.
(21) JH 213—Cook Mountain formation—From type Milams outcrop at base of scarp on the SW side of Antoine Creek, SW ¼, NE ¼, sec. 17, T. 13 N., R. 3 W., Winn Parish, La. About 6″ below zone of limestone concretions.

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JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 6, PP. 589–593, PL. 68, 3 TEXT FIGS., NOV., 1939

PERMIAN PELECYPOD GENUS *LIEBEA*[1]

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ABSTRACT—Pelecypods referred to *Liebea* Waagen have been recorded from Permian rocks at many localities in the eastern hemisphere and from eastern Greenland. The best known occurrences appear to be in rocks of Artinskian and Kazanian age, therefore, *Liebea* probably is a reliable guide to middle and upper Permian rocks. In founding the genus *Liebea*, Waagen completely misinterpreted its characters, although King previously had correctly described the species on which the genus was based. Since Waagen's time writers have perpetuated his original misconception of the genus. An examination of specimens of the genotype, *Liebea squamosa* (J. de C. Sowerby) (= *Mytilus hausmanni* Goldfuss) from England and Germany shows that *Liebea* is a typical member of the Myalinidae and does not have the peculiar hinge ascribed to it by Waagen. One extraordinary specimen, an external mold, retains the perfect imprint of the ligament, and sheds light on ligament characters of the Myalinidae and similar Paleozoic pelecypod families.

A SMALL mytiliform pelecypod commonly referred to *Liebea squamosa* (J. de C. Sowerby), 1829, or its more widely employed synonym *L. hausmanni* (Goldfuss), 1837, is widely distributed and locally abundant in the late Permian Zechstein-Kazan provinces of northern and northwestern Europe, and is associated with a Zechstein fauna in the east Greenland geosyncline (Frebold, 1931). The species has been reported also from the Italian Alps (Merla, 1931) and, doubtfully, from the Karoo beds of Tanganyika (Cox, 1936), and the Bone Springs and Capitan horizons of West Texas (Girty, 1908).

Similar species described under *Liebea* have been recorded from the *Bellerophon* beds of the Carnic alps (*Liebea dieneri* Gortani, 1906), and the uppermost Permian of Madagascar (*Liebea dieneri* Treat, 1933, not Gortani, 1906). Other species referred to *Liebea* have been described from the Lower Productus limestone (*Parafusulina* beds) of India (Waagen, 1881), and the Maping limestone of China, "early" Permian (Grabau, 1936).

Unfortunately, most of the references to *Liebea* have been based on external form without information on the ligament and internal characters which distinguish *Liebea* from other late Paleozoic mytiloid shells. The fact that the Permian rocks of many regions contain these diminutive shells which agree closely in form is of great stratigraphic interest and suggests that they may indeed all be closely related. It is urgent, however, that an attempt be made to determine whether or not all of the above mentioned forms possess the critical characters of *Liebea*.

[1] Acknowledgement is made to the University of Wisconsin Graduate School for funds devoted to this research, and to Frank E. Merchant, who assisted in the preparation of the illustrations. Dr. Paul Krynine generously translated an important article from Russian into English.

Characteristics of Liebea.—Waagen (1881, pp. 292–295) established *Liebea* on small mytiloid shells from the German Zechstein, characterized, as he thought, by the following features: (a) Byssal notch lacking, (b) ligament internal, lodged in a number of resilifer pits observable only in old specimens, (c) and by certain peculiarities of the anterior "auricles." His interpretation of the ligament was erroneous.

The original diagnosis is quoted:

> Shell inequivalve, the right valve smaller than the left one: inequilateral, mytiliform, with a small, not very distinct, posterior wing in both valves, and with a very small anterior wing in the left valve only. The position of this latter wing is not as in other Aviculidae, but is placed about vertically to the plane of the valve, turning round the smaller right valve and embracing it partially. This wing is compressed from both sides, bearing on its top a sharp ridge, which projects at about right angles from below and in front of the beak of the left valve, terminating the area of that valve anteriorly and giving it a squarish shape.
>
> In the right valve the existence of an anterior wing is barely indicated. In its place there is an incision of the shell, into which fits the bent-over anterior wing of the left valve.

Both valves are provided with a more or less distinct sharply defined area, which is linear in young specimens and very broad in old ones. It is smooth, and only covered by distinct striae of growth, parallel to the hinge margin.

The area in the left valve is broader than that in the right one.

The entire hinge line serves for the attachment of a quite internal ligament. This ligament seems to be linear in young specimens, but in old ones it is distinctly divided in several parts, which are attached to a number of pits, between which the hinge margins of both valves seem to have nearly touched each other. The number of pits is generally four or five. The first is situated just below the beaks, the others are distributed over the posterior part of the hinge line.

The hinge seems to have been quite edentulous, as no trace of teeth has been detected up to the present.

Internally, below and in front of the beaks, there is in each valve a small septum, which separates the anterior wing from the remainder of the shell.

The muscular and pallial impressions cannot be observed in any of the specimens at my disposal. They have been described accurately by King, only the position of the anterior adductor, as indicated by him, seems to be somewhat doubtful. If the anterior adductor had been attached to the anterior wing of the shell, it must have been much larger in the left than in the right valve, as in the latter this wing is so rudimentary that there was not much place for the attachment of a large muscle (Waagen, 1881, pp. 293–294).

King's observations on the same species are pertinent:

As J. de C. Sowerby and Goldfuss have overlooked two or three important characters of this interesting species, it is necessary for me to add, that it is inequivalved; has ecurved umbones, a horizontal septum within the umbonal cavity of each valve, and a wide longitudinally-grooved cartilage-furrow or fulcrum. Its muscular system has already been noticed; but it may be added, that the anterior visceral or pedal muscles, judging from the position of their impressions, must have been situated much furrher back than is usual in *Mytilus*—(King, 1850, p. 160).

It should be noted that King described the ligament area ("cartilage furrow") as being longitudinally grooved in *Liebea squamosa*, whereas Waagen described it as being smooth, marked only by growth lines. There can scarcely be any question as to King's meaning in reference to the ligament grooves, because he described and illustrated the same feature in another species generally

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EXPLANATION OF PLATE 68

FIGS. *1–5*—*Liebea squamosa* (Sowerby), genotype of *Liebea* Waagen, from late Permian horizons of western Europe. (p. 593)

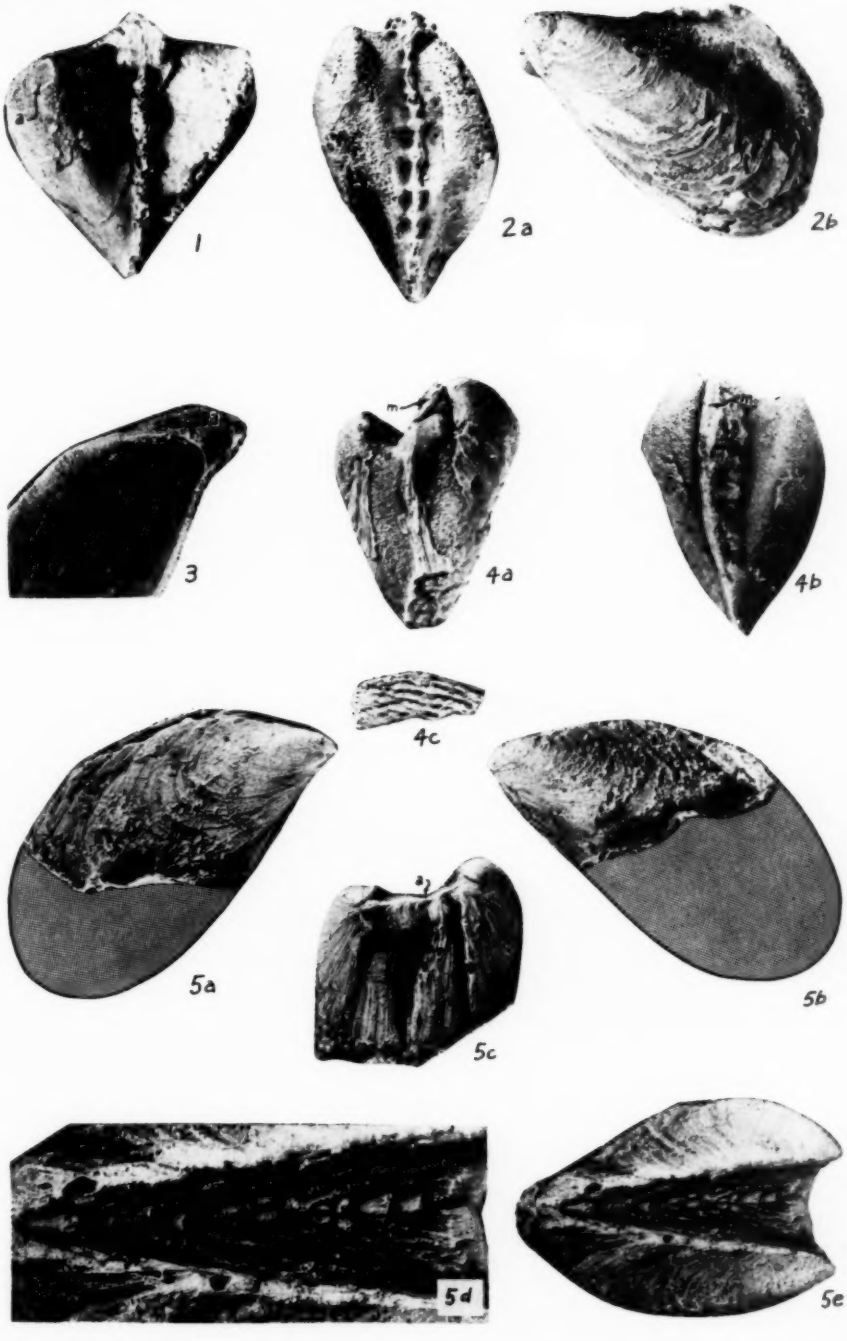
1—Dorsal view, internal mold, showing anterior (*a*), and posterior (*b*) byssal retractor muscle scars, ×3, from (Middle?) Zechstein of the Gera district, Germany. Landesmuseum, Berlin.

2a–b—Dorsal and left side views of another internal mold, showing general form, and the dorsal pustules along hinge line; these pustules, misinterpreted by Waagen, are simply the molds of the ventral termination of coarse ligament grooves of the *Myalina* type; ×3, from (middle?) Zechstein, near Gera, Germany. British Museum of Natural History, no. PL 243.

3—Rubber cast of left valve, showing anterior adductor pit (*a*), and umbonal septum (*s*), ×3. The general form of the species is not accurately shown due to imperfections of the original specimen, but the umbonal region appears to be perfectly represented. From middle Zechstein near Gera, Germany. Geologisches Landesmuseum, Berlin.

4a–c—Internal mold, extraordinary in retaining a fragment of external mold (*m*) showing ligament grooves, ×3; *4a*, front view; *4b*, dorsal view; *4c*, view of fragment (*m* in *4a–b*) of external mold retaining imprint of ligament grooves; all figures ×3. Middle Magnesian limestone, County Durham, England. British Museum of Natural History, no. PL 241.

5a–e—Rubber cast prepared from external mold of the most remarkable specimen of *Liebea* ever described, showing well the *Myalina*-like cardinal areas, and the form and distribution of the original organic structures of the ligament; from the oolitic beds of the middle Zechstein dolomite, near Gera, Germany. Geologisches Landesmuseum, Berlin. *5a*, Right side view, showing relatively smooth surface and mytiloid contour, ×3; *5b*, left side view showing the squamose growth lamellae of the left valve, ×3; *5c*, front view, sighted parallel to the hinge axis (*a*), ×3, showing prosogyre beaks, and peculiar crest or projection (tooth?) in the margin of the right valve which fits into a corresponding sinus in front of the beak in the left valve (see text figure 2); from the rugose and greatly thickened shell margins it appears likely that the individual is gerontic; *5d*, dorsal view of ligament, ×6, showing eight conical ligament bands, comparable with those in modern *Arca*, even the cross-striated surface of the chonchiolin structures being closely similar to ligament bands in the modern genus; *5e*, dorsal view, showing cardinal areas and ligament as seen with valves tightly shut, ×3; the right (lower) valve is slightly less convex than the left valve.



Newell, Permian Pelecypod Liebea

UNIV. OF MICH.

referred to the same genus, *L. septifer* (King) (1850, p. 161, pl. 14, fig. 13). *Liebea septifer* as described by King certainly had a ligament system similar to that of *Myalina* De Koninck, and judging from King's description of *Liebea squamosa*, this species also had a similar ligament.

found the hinge area marked only by parallel striations which he interpreted as growth lines. Maslennikov's plate 2, figure 11, indicates ligament grooves rather than growth lines on the hinge area of one imperfect specimen. He expressed somewhat hesitantly the possibility that the Russian

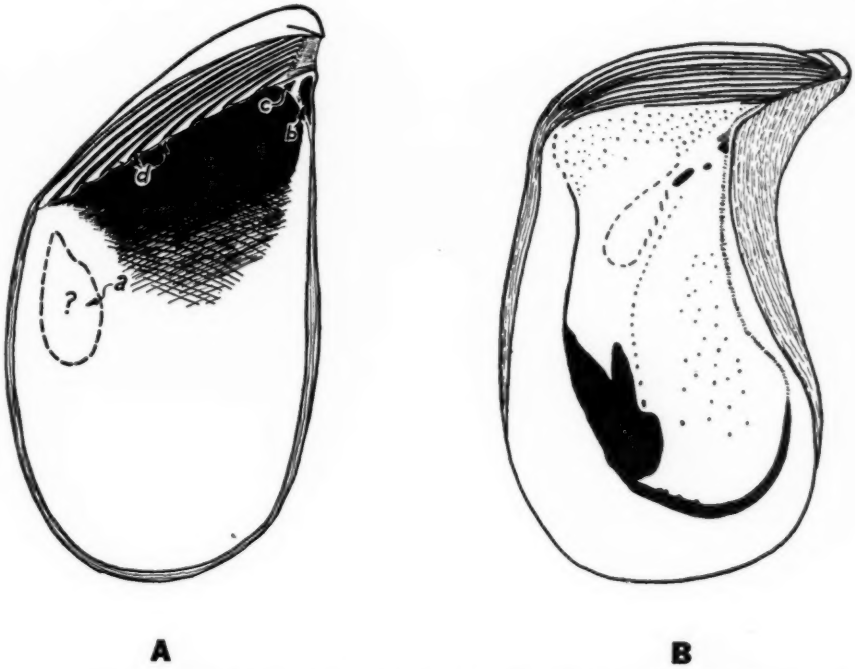


FIG. 1.—Comparison of *Liebea* and *Myalina*. A, *Liebea squamosa*, diagrammatic restoration of hinge characters, based on specimens from the middle Zechstein at Gera, Germany. *a*, Posterior adductor, position approximately correct, form uncertain; *b*, pit for anterior adductor, apparently located upon, and at anterior margin of the septum *c*, which walls off an umbonal cavity; *d*, ligament grooves, all of which intersect the hinge axis, as contrasted with *Myalina*. B, *Myalina* (*sensu lato*), composite diagram based on camera lucida drawings of several specimens from the Lecompton limestone of Kansas (Pennsylvanian); features of musculature and mantle insertions shown in black. In this type of shell the ligament grooves are almost parallel to the hinge axis. Generally only two or three of the ligament grooves reach the hinge axis at the base of the ligament area.

Since Waagen's day there apparently has been no critical reinvestigation of the characters of *Liebea*. Maslennikov, while studying Kazanian specimens from the Timan Mountains of northern Russia, was puzzled at being unable to confirm Waagen's observations on *Liebea* (Maslennikov, 1935, pp. 63–66). After cleaning some of the Russian specimens, he concluded that the hinge does not possess multiple resilifers such as those described by Waagen. Instead, he

species may differ from the Zechstein *L. hausmanni* (=*L. squamosa*), pointing out that the Russian form lacks the peculiar anterior auricle on the left valve and that the musculature varies slightly from descriptions of the western European specimens. He might have added also that the specimens illustrated by him differ considerably in form from the Zechstein representatives, and have a much narrower ligament area. Although the Russian form was described

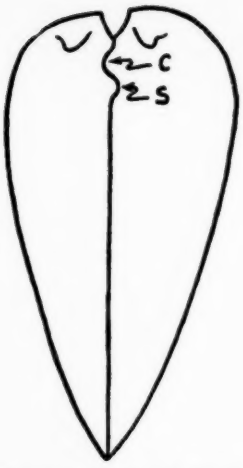


FIG. 2.—Diagram of front aspect of *Liebea squamosa*, reconstructed from mature growth stage of the gerontic specimen shown on plate 68, figure 5c, *c*, Crest; *s*, Sinus in margin of left valve, interlocking with corresponding crest and sinus in the margin of the right valve.

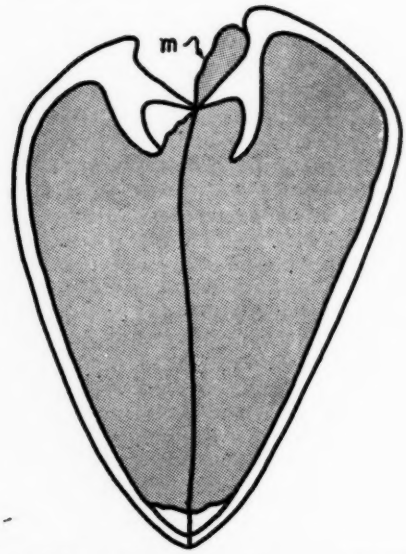


FIG. 3.—Diagram of specimen illustrated on plate 68, figure 4a; stippled area represents internal and external (*m*) mold; outline of original shell restored; imprint of ligament area preserved on under side of the fragment of the external mold (*m*). Since the external molds of shells such as this are difficult to collect only the rarest of specimens now in museums show the characters of the ligament area. Internal molds of pelecypods having an external ligament seldom give any clue as to the nature of the ligament.

under the name *Liebea hausmanni*, Maslennikov intimated that perhaps his material should be classed with *Myalina* instead of *Liebea*.

When Waagen framed the original diagnosis of *Liebea*, he had under consideration two species, *Liebea hausmanni* (Goldfuss) from the German Zechstein, and *L. indica* Waagen from the basal beds of the lower Productus limestone of India (horizon of primitive *Parafusulina*). Although most of Waagen's observations were made on the German species, he failed to designate it as the genotype, therefore the two species were genosyntypes. The first formal designation of a genotype for *Liebea*, to my knowledge, was made by Cox (1936, pp. 38–39) when he indicated *Liebea squamosa* as the type of *Liebea*. This designation is valid, in the absence of earlier designations, inasmuch as Cox placed *L. hausmanni* in the synonymy of the earlier described *L. squamosa*. It is my opinion that the two names, as indicated by Cox, are subjective synonyms. Although the species *squamosa* would not be recognizable from Sowerby's description of 1829, King (1850) redescribed the species with Sowerby's specimens before him. Apparently no one has questioned the identity of the form described by King as *squamosa* with the German *hausmanni* of Goldfuss.

Through the generosity of Mr. Kenneth Oakley of the British Museum of Natural History, I have before me four specimens of *Liebea squamosa*. Two of them are from the Magnesian limestone of England, and are essentially topotypes of Sowerby's species. The other two are from the Zechstein of Gera, Germany, the locality that yielded Waagen's specimens. All of the specimens are internal molds, as were most of Waagen's. One of the English specimens is extraordinary in retaining a portion of the external mold of the ligament area of the left valve. This specimen (plate 68, figures 4a–c), although imperfect, clearly had a ligament like that of *Myalina* in general construction, but differed in a few significant respects.

Another collection of specimens was made available for this study from the collections of the Geologisches Landesmuseum at Berlin, through the kindness of Dr. O. H. Schindewolf. These specimens are all from

the Zechstein dolomites of the Gera district. Some, perhaps all of them, are from the middle Zechstein horizon. The more instructive specimens consist of six internal molds, some of which exhibit features of musculature, and one incomplete but superb external mold, which shows perfectly the ligament characters and form of the shell (plate 68, figures 5a–e). This specimen is unique among all described Myalinidae in showing perfectly the imprint of the original conchiolin structures of the ligament, and verifies my prediction (Newell, 1938, pp. 34–35, pp. 26–30, figure 6) that the ligament of *Myalina* and similar Paleozoic shells was comparable structurally to that of modern *Arca*. With the new data on the characters of the genus it is appropriate to formulate a revised diagnosis.

Family MYALINIDAE Frech
Genus LIEBEA Waagen, 1881
Plate 68, figures 1–5e

Shell small, rarely attaining a length greater than 2.5 centimeters, mytiloid, subrhombic, lacking anterior lobation, relatively convex, subequivalve, with right valve almost imperceptibly less convex than the left valve; surface devoid of radial ornamentation, right valve relatively smooth, left valve more or less conspicuously lamellose; anterior margin of both valves crenulated just below the beaks by one crest (dysodont tooth?) and one sinus (socket?) each, the crest of the left valve being above the sinus and that of the right valve being placed below a sinus, crests and sinuses interlocking in the two valves to produce a sort of dentition; hinge myalinoid, and in the ordinary sense edentulous, gaping ligament areas covered by rather steeply inclined ligament grooves, of which six to eight intersect the hinge axis in adults of the genotype and are expanded slightly at the hinge axis so that the ends of the grooves are marked on internal molds by prominences or knobs; anisomyarian, with the anterior adductor lodged in a pit along anteroventral edge of an umbonal septum, which walls off a rather deep umbonal cavity, posterior adductor apparently located rather close under posterior extremity of hinge; byssal retractors two, one located at apex of umbonal cavity, the other somewhat posterior to the first one.

From *Myalina*, as ordinarily understood, *Liebea* is distinguished by the fact that a large number of ligament grooves intersect the hinge axis (six or eight in *Liebea*, two to four in *Myalina*), and by the interlocking crests and sinuses of the anterior margin in *Liebea*. No species of *Myalina* has been described in which the anterior adductor is placed at the front margin of an umbonal septum.

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DIMENSIONS OF *LIEBEA SQUAMOSA* FROM ZECHSTEIN NEAR GERA[1]

Specimen	1	2	3	4	5	6
Length	—	18 mm	16 mm	17 mm	22 mm	15 mm
Height	—	15 mm	14 mm	14 mm	15 mm	12 mm
Thickness	10 mm	10 mm	12 mm	11 mm	—	9 mm
No. lig. grooves	8	7	7	8	—	8

[1] All the specimens are bivalved internal molds except no. 1, which is a cast.

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SOME FUSULINIDS FROM THE MISSOURI SERIES OF KANSAS

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Kansas Geological Survey, Lawrence, Kansas

ABSTRACT—Five species of *Triticites* are described from the Missouri series of Kansas. Two of them are new species and one a new variety. A statistical method of study and a graphical representation of the characters are employed. A new species from the Wyandotte formation is a form previously included in *T. irregularis*. A new species from the Plattsburg formation is an advanced form both in its elongate-ventricose shape and intense septal fluting. Had it been found in strata of questionable age, it might well have been classed as post-Missouri in age.

SINCE the publication of the epochal work on Mid-Continent fusulinids by Dunbar and Condra (1927), the Missouri series has generally been known as the zone of *Triticites irregularis*, or the zone of primitive *Triticites*. Originally *Triticites irregularis* (Schellwien and Staff) as emended by Dunbar and Condra, was the best known Missourian species, because it was relatively abundant in collections of the latter investigators. More recently, however, it was shown by Newell (1934) that all Missourian fusulinids having the general form of *T. irregularis* cannot properly be referred to that species. One of the results of the present study is the recognition that *T. irregularis, sensu stricto*, appears to be confined to the Dennis limestone in the lower part of the Missouri series and is replaced at higher horizons by other easily distinguished forms. Two of these are described here as new species. Other forms are inadequately represented in our collections and must, therefore, wait description until a future date.

A *Triticites* occurring rather commonly in the Lansing group in the upper part of the Missouri series is very similar to *Triticites secalicus* (Say) of the lower Virgil and has been so identified (Dunbar and Condra, 1927). Statistical studies show that the Missourian form is persistently distinct from the later one, so that it has seemed appropriate to give it a separate name.

The writers wish to express their thanks to Dr. Norman D. Newell, under whose direction the research was carried on. We wish to acknowledge the generosity of Dr. Raymond C. Moore who made the collection of the Kansas Geological Survey available for this study.

The stratigraphic classification of the Pennsylvanian of the northern Mid-Continent region used in this paper is that published in the Guide Book of the Eleventh Annual Field Conference of the Kansas Geological Society, 1937.

The Missouri series is a unit bounded above and below by unconformities. The Bourbon formation, at the base, consists of 150 to 200 feet of clastics and is immediately overlain by the Bronson group. The latter consists of three thick limestone members, separated by two thinner shales. The total thickness is about 100 feet. Next above is the Kansas City group, which is about 200 feet thick. It is characterized by the variability of its limestones and the greater prominence of shale. The Lansing group, which overlies the Kansas City, consists of two prominent limestone formations separated by a thick shale. This group is about 75 feet thick in northeastern Kansas. At the top of the Missouri series there are from 40 to 200 feet of clay shale followed by the thin Iatan limestone. These two divisions are included in the Pedee group. Much, and in many places all, of the Pedee group is cut out by the post-Missouri unconformity.

According to Dr. Norman D. Newell (personal communication) *Triticites* occurs in the lower part of the Bethany Falls limestone member of the Swope formation (scanty specimens of *Triticites* along with

the more common *Wedekindellina ultimata*); throughout the Winterset limestone member of the Dennis formation; the Block limestone; the lower part of the Westerville limestone; the Dewey limestone of northern Oklahoma (which is the equivalent of the Cement City limestone member of the Drum formation); the Paola limestone member of the Iola formation; the Frisbie limestone, Island Creek shale and lower Farley limestone members of the Wyandotte formation; the Merriam and Spring Hill limestone members of the Plattsburg formation; the Captain Creek, Stoner and South Bend limestone members of the Stanton formation; and in the Iatan limestone at the top of the series. Thus, most of the limestones in the Missouri series contain *Triticites*.

Described species, however, are recorded from only the following horizons in the northern Mid-Continent region: Winterset limestone of the Dennis formation (*Triticites irregularis*), Bethany Falls limestone of the Swope formation (*Wedekindellina ultimata*), Island Creek shale member of Wyandotte formation (*Triticites tenuis*, n. sp.), Farley limestone of the Wyandotte formation (*Triticites cf. osagensis*), Springhill limestone member of the Plattsburg formation (*Triticites plicatulus*, n. sp.), Dunbar and Condra's (1927, p. 108) "Plattsburg limestone" ("*Triticites secalicus*"), Captain Creek member of the Stanton formation (*Triticites neglectus*), Stoner limestone member of the Stanton formation (*Triticites secalicus primarius*, n. var. and *T. osagensis*) and the South Bend member of the Stanton (*Triticites cf. moorei*).

Insufficient material was available for inclusion of other Missourian *Triticites* in this study.

Triticites has also been described from Missourian equivalents in other parts of the United States. Several species have been described from Texas by White (1932). In north-central Texas, from the East Mountain and Keechi Creek shales of the Mineral Wells formation, he describes *Triticites irregularis*, "Fourth Form"; from the Palo Pinto limestone, *Triticites irregularis*, "Second Form" and "Third Form"; and from the Brownwood shale member of the Graford formation, *Triticites irregularis*, "First

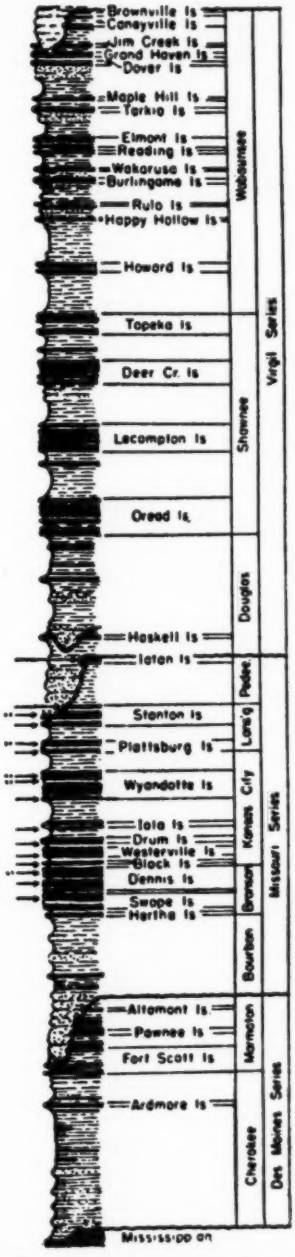

FIG. 1.—Stratigraphic section of the Pennsylvanian rocks of the northern Mid-Continent region. Limestones shown in solid black. Arrows indicate known fusulinid-bearing horizons in the Missouri series. Arrows with dots indicate horizons from which the fusulinids described in this paper were obtained (Section after Newell and Keroher).

Form." He also records *Triticites irregularis* "Fourth Form" from the lower Gaptank formation of the Glass Mountains area.

Thompson (1936, b) has described a Missourian Triticite, *T. ohioensis*, from the Brush Creek and Cambridge limestones of the middle Conemaugh of Ohio. He (1936, a) also describes two species, *T. milleri* and *T. submucronata*, from the Hartville formation of Wyoming. He states (ibid., p. 98) that on the basis of the fusulinids, these beds are probably upper Missouri or lower Virgil in age.

From the Magdalena formation of New Mexico, Needham (1937) has recorded and described a number of species of *Triticites*. He thinks (ibid, p. 16) that the lower part of this zone of *Triticites* is correlated with the Missouri series of the northern Mid-Continent region and the Canyon series of Texas, and bases his conclusion on the presence of *Triticites nebraskensis* in this lower zone, the middle Magdalena. The species he describes are *Triticites nebraskensis*, *T. wellsi* and *T. cuchilloensis*, and these may be said to be probably Missourian in age.

It is generally agreed that the uppermost occurrence of the brachiopod genus *Mesolobus* marks the top of the Des Moines series. Also, it is generally accepted that *Triticites* first appears in the Missouri series. There are possibly two exceptions to these occurrences: According to P. B. King (1928), an undescribed species of *Triticites* with extremely thick walls occurs in the basal Gaptank of the Glass Mountains. He states that in the next fossiliferous layer above, Schuchert reports *Chonetes mesolobus* (now *Mesolobus mesolobus*). Here, then, unless either of the identifications be incorrect, the two zones overlap. Perhaps the *Triticites* found by King is a form more primitive than any of the known Missourian species and perhaps here is a section representing a part of the hiatus which separates the Des Moines from the Missouri in some of the Mid-Continent sections.

Another example of a possible overlapping of the zones of *Mesolobus* and *Triticites* occurs in north-central Texas. White (1932, p. 52) records the rare occurrence of two species of *Triticites*, *T. irregularis*, "*Fourth Form*" and *T. sp. A*, from the East Mountain shale, Mineral Wells formation, just below the Lake Pinto sandstone. According to a chart given in the latest work on the Chonetidae and Productidae of this region by Ralph King (1938, p. 258) *Mesolobus mesolobus* and *Mesolobus euampygus* occur in the lowest of three zones in the Mineral Wells formation. Whether or not the highest occurrence of *Mesolobus* is above the lowest occurrence of *Triticites* cannot be ascertained from the literature, since the exact upper limit of the *Mesolobus* is not stated, but it appears possible that here, also, the two zones overlap.

It can readily be seen by studying the literature that correlations have been made almost entirely on the basis of genera of fusulinids. Any evolutionary trends that have been worked out for the Fusulinidae have been in almost all cases based on genera alone, and little attempt has been made to discover any direction of evolution among the species within a single genus. The zone of *Triticites* includes several hundred feet of strata, from the base of the Missouri series up into the Big Blue series and within this zone there have been approximately forty species of *Triticites* described, with probably at least half that many more collected but undescribed from the Virgil subseries of the northern Mid-Continent region. From the base to the top of this zone, the species vary widely in shape, intensity of septal fluting, and in many other specific characters. Since the zone of *Triticites* includes fusulinids not all of one general character, but of many, it should be possible by study of an abundance of material from all of the fusulinid-bearing horizons to work out trends within the genus *Triticites* thus enhancing its stratigraphic value.

When this study of the Missourian *Triticites* was begun, it was hoped that some conclusions, or at least hints, relative to evolution within the genus *Triticites* might be obtained. Evolutionary trends have not been recognized in this work, possibly due to the following facts:

First, the collections available for study came mainly from eastern Kansas, with only a few from western Missouri and southern Iowa. It is believed that a more complete picture could be obtained if the

collections involved a wider area. Second, it is known that fusulinids occur in almost every limestone horizon in the Missouri series, but the collections available for study represent only five of them, namely, the

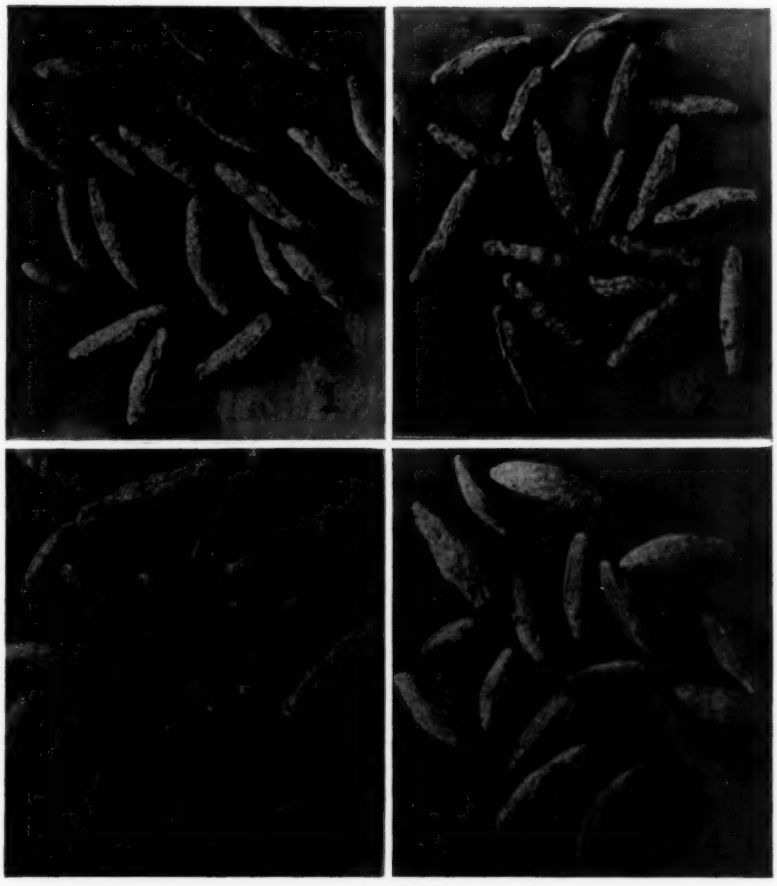

FIG. 2—1. *Triticites irregularis* (Schellwien and Staff), emend. from the Winterset limestone at Winterset, Iowa, ×2.
2. *Triticites tenuis*, n. sp. from the Island Creek shale, Miami Co., Kansas, ×2. Note the close similarity to *T. irregularis*.
3. Specimens of *Triticites secalicus* (Say) var. *primarius*, n. var. from the Stoner limestone, Woodson Co., Kansas, ×2.
4. Topotype specimens of typical *Triticites secalicus* for comparison with *T. secalicus primarius*, ×2. Note the more inflated form of the former.

Winterset limestone member of the Dennis formation, the Island Creek shale and Farley limestone members of the Wyandotte formation, the Springhill limestone member of the Plattsburg formation, and the Stoner limestone member of the Stanton formation. By referring to the accompanying section it can be seen that there is a considerable stratigraphic interval between horizons represented by fusulinids in our collections. The gap in our information between the Dennis and Wyandotte formations is especially great. Several fusulinid horizons are known to exist in this section, and more extensive collections might reveal trends that at present are unrecognized. If there are any evolutionary trends in the

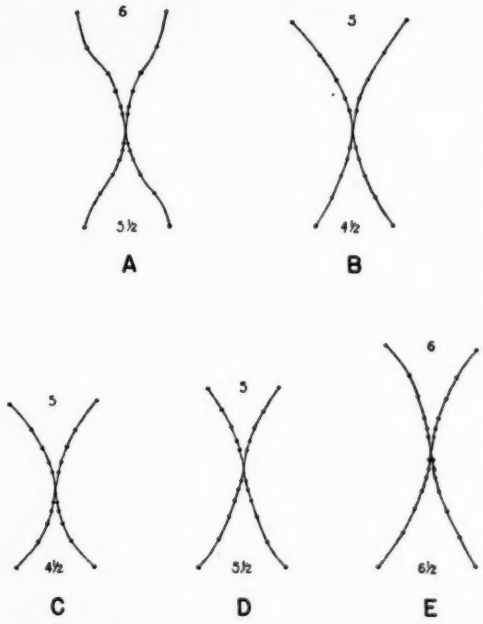

FIG. 3.—Diagrammatic representation of the average shape of the tunnel angle of A, *Triticites secalicus* (Say) var. *primarius*, n. var.; B, *Triticites plicatulus*, n. sp.; C, *Triticites irregularis* (Schellwien and Staff) emend.: D, *Triticites tenuis*, n. sp.; E, *Triticites* cf. *osagensis* Newell. These symmetrical diagrams were constructed from irregular tunnels in order that they may be directly comparable. They represent the average shape for the species, and not any single specimen.

Triticites of the five horizons studied, they could easily be unnoticed because of the great gaps between them.

Still another obstacle to working out evolutionary series lies in the fact that in some of the horizons, the upper Plattsburg for instance, two forms varying widely in external shape occur together. These forms have no obvious relationships, except that both belong to the genus, *Triticites*.

It is believed that with more intensive collecting over a greater area and from intermediate horizons, the above difficulties can be overcome, and definite indications as to the evolution of the Missourian *Triticites* can be obtained.

METHOD OF STUDY AND DESCRIPTION

One of the results of this investigation is the conviction that the only means by which the characters of a fusulinid species can be determined accurately and clearly is a statistical method of study, accompanied by graphic presentation. Considerable difficulty is encountered in comprehending really significant features in many elaborate descriptions found in current literature, due in part to a tendency toward generalization. As described fusulinid species increase in number, it is becoming more apparent that attempt should be made to determine the limits of variation within a species and to discover average values between those limits that represent the typical form. If such data are not published, precise comparison of different species from the literature becomes almost impossible.

Maynard White (1932, p. 14) has said in protest against the use of subjective descriptions,

> . . . even on the basis of some standard of comparison any worker is likely to describe the same individual test differently at different times. Such terms are relative and increase the element of human error, which should always be kept to a minimum.

Certain characters, such as septal fluting and nature of chomata, can only be described by the use of descriptive phrases, and they should be illustrated by good photographs, for no truly objective method for studying these characters has been devised. However, in much of the literature, characters that might conveniently have been shown by tables or charts are either scattered throughout the text or completely omitted. A description should be so set forth that if a reader disagrees with an interpretation or questions it, he can easily discriminate observational data on which that interpretation was based. A statistical method of study seems to be the best approach to the study of the fusulines.

In the present study, wherever possible, at least 10 good axial and 10 good sagittal sections along with several tangential sections were studied. Negative photographic prints were made at a magnification of exactly 50 diameters, and almost all of the measurements were made from these prints under a binocular microscope using a scale divided into 0.5 mm. Using this scale and magnification, each small division on the

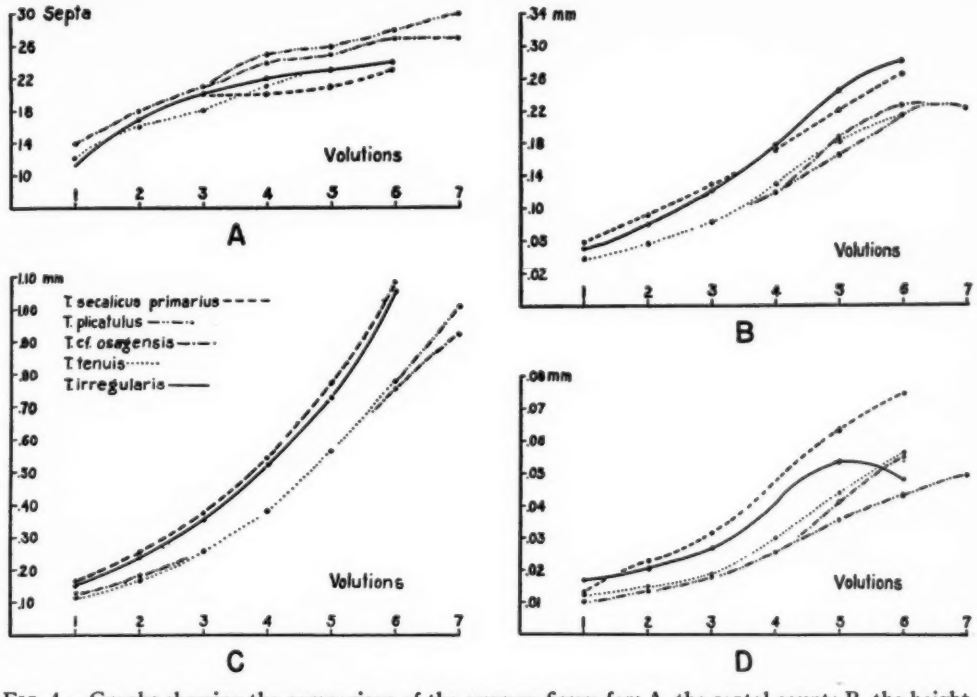

FIG. 4.—Graphs showing the comparison of the average figure for: A, the septal count; B, the height of volution; C, the radius vector; and D, the wall thickness of the five species studied. The measurements used for plotting these graphs are the averages given in the detailed charts of these characters.

scale equals 10 microns, thus eliminating much computation in recording the measurements. A petrographic microscope was used in making the negative prints. It was found that in many cases greater definition could be obtained by using crossed nicols.

The measurements were recorded in a manner similar to that followed by Dunbar and Skinner (1937) giving wherever possible the measurement per volution and not merely a single, general measurement for the entire shell. In addition, it was found desirable to show several of the characters in graphic curves. This method was used by Newell and Keroher (1937) and it is of obvious value for purposes of comparison. Specific difference can be comprehended at a glance where the characters of two or more species are superimposed on a single graph.

SPECIFIC CHARACTERS

In general, the specific characters used are those set forth by Dunbar and Skinner (1937), and in most cases their suggestions as to method and place of measurement were followed. However, certain characters are in need of further explanation and discussion.

The tunnel angle is the angle subtended by the walls of the tunnel as measured from the center of the proloculum, and should be measured for each volution. The limits of the tunnel are marked approximately by the chomata, and the tunnel angle is measured from the center of the proloculum to some point on the chomata. Study of the literature does not indicate the point on an individual choma where the tunnel angle should be measured. Since, at least in the *Triticites* studied, the chomata in many specimens are very broad and low, different students studying the same axial section might obtain widely varying results due to lack of uniformity in the method of making this measurement. In almost all of the sections of *Triticites* studied, the juncture of

the tunnel with one or more septa could be seen. In these instances measurements were taken at the greatest transverse dimension of the perforation of the septum. These points usually fall about halfway up the inside slope of the chomata.

In this paper, the half length and the form ratio are given for only the last volution of mature individuals. Dunbar and Skinner (1937), give measurements of these characters for each volution. Since, at least for the *Triticites* studied, the septal fluting in the axial zone of each volution is rather intense, the polar extremities of each volution can not be ascertained with any degree of accuracy. Also, a section seldom is so oriented that each complete volution is shown. Therefore, it seems impractical to try to obtain measurements of the half length and form ratio for all volutions.

Maynard White indicates that characters of the wall structure can and should be measured with "mathematical precision." The characters he mentions (White, 1932, p. 13) as deserving of greater taxonomic importance are the size and character of alveolar tubes; component parts of the wall, in forms in which these parts can be differentiated, and their relative thickness; the thickness of the whole wall structure; and the height of volution. Probably most of these characters are of importance, but in few sections studied has it been possible to measure accurately either the number of alveoli or lamellae in the keriotheca, or pores in the tectum, per unit section of the wall. In order to see these features well enough to measure them, not only are exceptionally fine sections required, but also the specimens must be particularly well preserved. In but very few of the specimens studied was the preservation such that these characters could be measured, and in Missourian fusulinids at hand they do not lend themselves to an accurate statistical analysis. However, in the present study, considerable attention has been given to the thickness of the wall and the height of volution.

SYSTEMATIC DESCRIPTIONS

TRITICITES IRREGULARIS (Schellwien and Staff) emend.

Plate 69, figures 4–6; text figure 2–1

Triticites irregularis DUNBAR and CONDRA, *1927 (pars)*, Nebraska Geol. Survey, Bull. 2, 2d series, pp. 108–111, pl. 8, figs. 7–10, pl. 9, figs. 1–3.

Shape.—Elongate, slender, with rather irregular, pointed extremities. The earlier ontogenetic stages are considerably more

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EXPLANATION OF PLATE 69

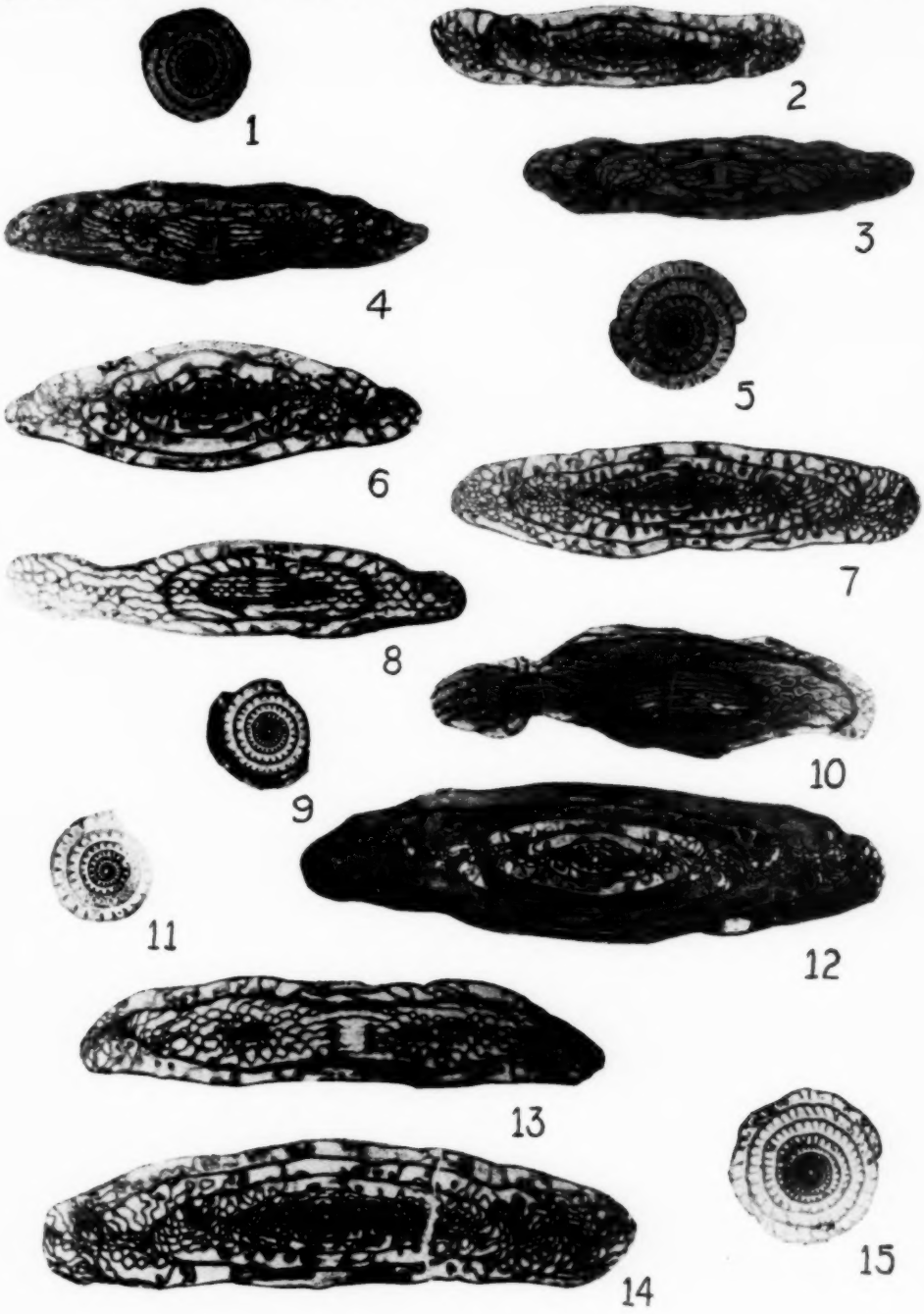
FIG. *1–3—Triticites tenuis* Merchant and Keroher, n. sp. All specimens from the Island Creek shale, Miami Co., Kansas. All ×10. *1*, Sagittal section of a paratype, Univ. of Kansas type no. 3363-B 1. *2*, Axial section of holotype showing the normal characters of the species, Univ. of Kansas type no. 1118-A 1. *3*, Tangential section of a paratype (note that septal fluting is more intense than that of *T. irregularis*, fig. 4), Univ. of Kansas type no. 3363-C 1. (p. 604)

4–6—Triticites irregularis (Schellwien and Staff) emend., all ×10. *4*, Tangential section showing weak fluting across middle becoming irregular and blisterlike in the polar zone. Winterset limestone at Winterset, Iowa., Univ. of Kansas type no. 2541. *5*, *6*, Sagittal and axial sections showing typical characters of the species. Specimens from Winterset limestone, Miami Co., Kansas, Univ. of Kansas type nos. 3383 and 3383. (p. 600)

7–9—Triticites cf. *osagensis* Newell. All specimens from the Farley limestone at Loring, Kansas. All ×10. *7*, Axial section of a typical specimen, Univ. of Kansas type no. 3548. *8*, Tangential section showing characteristic intense fluting, Univ. of Kansas type no. 3548. *9*, Sagittal section, Univ. of Kansas type no. 3548. (p. 606)

10–12—Triticites secalicus (Say) var. *primarius* Merchant and Keroher, n. var. All specimens from the Stoner limestone, Woodson Co., Kansas. All ×10. *10*, Tangential section of a paratype showing weak fluting across the middle of the shell becoming more intense and still regular in the polar zones, Univ. of Wisconsin type no. 20842. *11*, Sagittal section of a paratype, Univ. of Wisconsin type no. 20841. *12*, Axial section of the holotype, typical of the variety. (p. 611)

13–15—Triticites plicatulus Merchant and Keroher, n. sp. All specimens from the Springhill limestone near Garnet, Kansas. All ×10. *13*, Tangential section of a paratype showing the quite intense but rather irregular septal fluting, Univ. of Kansas type no. 6819-B 1. *14*, Axial section of the holotype showing the very complex character of the septa in the axial zone and the weak chomata, Univ. of Kansas type no. 6819-A 1. *15*, Sagittal section of a paratype, Univ. of Kansas type no. 6819-B 1. (p. 609)



Merchant and Keroher, Mid-Pennsylvanian Fusulinids

UNIV. OF MICH.

inflated and the ends are blunter than in the mature shell.

Number of volutions.—Mature individuals have from 6 to 6½ volutions, but a few were observed to have as many as 7.

Septa.—Septal furrows generally broadly sinuous, rarely straight; septa nearly plane to slightly irregular across the middle of the shell becoming moderately and irregularly fluted toward the poles. The septal folds near the polar extremities are irregular, blister-like structures, the loops of one sep-

MEASUREMENTS

Specimen	*Half length* (mm)	*Form ratio*	*Diam. of proloculum*(mm)
1	3.5	3.7	.134
2	3.4	4.2	.137
3	3.6	3.2	.138
4	3.9	3.7	.139
5	3.3	4.1	.140
6	3.6	3.3	.140
7	3.4	3.6	.141
8	4.1	4.0	.142
9	4.4	3.8	.142
10	3.5	3.5	.143
Ave.	3.8	3.6	.139
Max.	4.4	4.1	.143
Min.	3.4	3.2	.134

RADIUS VECTOR (MILLIMETERS)

Volution Specimen	1	2	3	4	5	6
1	.125	.195	.295	.440	.650	—
2	.140	.195	.305	.480	.700	—
3	.145	.220	.320	.465	.690	.960
4	.135	.210	.340	.565	.820	1.055
5	.175	.260	.375	.545	.785	1.125
6	.140	.235	.350	.525	.815	1.120
7	.170	.260	.420	.605	—	—
8	.150	.260	.360	.535	.715	—
9	.135	.195	.295	.455	.680	—
10	.180	.285	.425	.630	—	—
Ave.	.150	.230	.350	.525	.731	1.060
Max.	.180	.285	.425	.630	.820	1.125
Min.	.125	.195	.295	.440	.650	.960

SEPTAL COUNT

Volution Specimen	1	2	3	4	5	6
1	10	17	21	23	22	23
2	12	15	19	23	24	—
3	13	17	20	22	25	22
4	11	17	19	20	23	25
5	9	16	19	23	30	23
6	11	18	20	24	23	22
7	10	17	22	20	22	28
8	12	17	20	22	24	26
9	14	17	19	26	25	—
10	12	16	20	19	24	23
Ave.	11	17	20	22	23	24
Max.	14	18	22	26	24	28
Min.	9	15	19	19	20	22

HEIGHT OF VOLUTION (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6
1	.045	.076	.137	.220	.260	—
2	.043	.076	.102	.144	.210	—
3	.064	.086	.115	.171	.238	.255
4	.052	.094	.117	.177	.291	—
5	.060	.091	.155	.192	—	—
7	.058	.090	.125	.180	.220	—
7	.045	.065	.100	.157	.225	—
8	.048	.068	.103	.180	.239	—
9	.047	.075	.106	.146	.220	.270
Ave.	.050	.080	.120	.175	.244	—
Max.	.065	.095	.155	.220	.291	—
Min.	.045	.065	.100	.145	.210	—

tum not being in regular apposition with those of the adjacent septa. Septal pores are small and rare and appear to be confined to the last two volutions of mature shells.

Character of wall.—The wall consists of tectum and keriotheca. The tectum is very thin, averaging between 5 and 7 microns in thickness in the fifth and sixth volutions. The thickness of this wall layer appears to remain about the same in all volutions, but this apparent uniformity may be due to the fact that the tectum is quite thin and consequently is very difficult to measure accurately. The keriotheca averages about 47 microns in thickness in the fifth and sixth volutions. This is the element of the wall which appears to be the most variable, but the apparent variability may be due to the fact that the keriotheca is much thicker than the tectum and its variations are more easily measured. The keriotheca appears to be very fine-textured, but the fineness may be only apparent, due to poor preservation.

Chomata.—The chomata in this species are well developed and vary considerably in size and shape, some being quite high and narrow, others, low and broad. The chomata are absent only in the last volution, disappearing about one volution from the antetheca.

Tunnel.—The tunnel is irregular and tends to widen in successive volutions so that the tunnel angle cannot be expressed by a single measurement.

Discussion.—This species is one of several included in Staff's (1912) *Fusulina centralis irregularis*. Dunbar and Condra (1927) restudied the form and found that it included at least four species representing two genera, *Fusulina* and *Triticites*. Consequently, they restricted the name, *Triticites irregularis*, so that it included a group of similar *Triti-*

WALL THICKNESS (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6[1]
1	.017	.026	.030	.042	.050	.048
2	.017	.030	.030	.055	.060	—
3	.018	.018	.028	.035	.057	—
4	.017	.022	.027	.034	—	—
5	.018	.020	.035	.045	—	—
6	.019	.016	.025	.030	.055	.050
7	.017	.020	.025	.038	.055	—
8	.016	.019	.027	.055	.057	.050
9	.018	.025	.028	.040	.050	.048
10	.018	.017	.025	.035	.050	—
Ave.	.017	.021	.028	.041	.054	.049
Max.	.019	.030	.035	.055	.060	.050
Min.	.016	.016	.025	.030	.050	.048

[1] The figures given for the wall thickness of the sixth volution are based on insufficient material to indicate the true limits of variation.

TUNNEL ANGLE (DEGREES)

Volution / Specimen	1	2	3	4	5[1]
1	19	19	32	49	45
2	13	20	30	42	76
3	15	22	35	55	—
4	22	28	31	43	—
5	16	29	32	36	—
6	22	25	37	56	—
7	16	23	31	35	44
8	16	21	31	44	73
9	13	23	33	51	—
10	17	25	37	55	—
Ave.	17	24	33	47	59
Max.	22	29	37	56	76
Min.	13	19	30	35	44

[1] The average figure for the tunnel angle of the fifth volution is less significant than for the other volutions because of insufficient data.

cites ranging, in the northern Mid-Continent region, from the Winterset limestone of lower Missourian age to the upper Deer Creek formation of the Virgil series. They designated no type locality or horizon, but the forms they figured came from the Winterset limestone (formerly called Dekalb) at Winterset, Iowa. It is now recognized that *Triticites irregularis* of Dunbar and Condra includes several different species. At the present time, the form from the Winterset limestone is considered typical of the species, and it is the tendency to restrict the name *Triticites irregularis* to the Winterset form. Newell (1934, p. 423) states, "Dunbar regards as typical *T. irregularis*, the form occurring abundantly in the Winterset limestone at Winterset, Iowa." Thompson (1936) also indicates that the Winterset form is typical of the species. In this paper also, then, the Winterset species is considered typical *Triticites irregularis*.

This species is characterized by its elongate, slender form with rather pointed, irregular polar extremities; by its septa which are nearly plane to slightly irregular across the middle of the shell, becoming moderately but quite irregularly fluted toward the poles.

Occurrence.—Winterset limestone, five miles southwest of Winterset, Iowa, and Winterset limestone at Block, S ¼ cor. sec. 6, T. 18 S., R. 24 E., Miami County, Kansas.

Hypotypes.—Type numbers 3383, 3383 and 2541. Repository—University of Kansas.

DIMENSIONS OF SPECIMENS OF TRITICITES TENUIS

Specimen	*Half length* (mm)[1]	*Form ratio*[1]	*Diam. of proloculum* (mm)
1	4.2	4.9	.100
2	3.5	4.0	.096
3	3.9	4.6	.115
4	4.0	5.0	.093
5	4.4	4.5	.098
6	4.0	4.5	.091
7	3.8	4.3	.107
8	4.0	4.5	.095
9	3.8	4.4	.113
10	3.9	4.6	.100
Ave.	4.0	4.5	.101
Max.	4.4	5.0	.115
Min.	3.5	4.0	.091

[1] The measurements of the half length and form ratio were taken from specimens with from 6 to 6½ volutions.

TRITICITES TENUIS Merchant and Keroher, n. sp.

Plate 69, figures 1–3; text figure 2–2

Shape.—Quite slender and elongate, with rather irregular, pointed extremities. The first few volutions are considerably blunter and more inflated than the mature shell.

Number of volutions.—Mature individuals of this species have from 6 to 6½ volutions, but a few individuals have as many as 7.5.

RADIUS VECTOR (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6
1	.095	.145	.220	.335	.480	.675
2	.125	.190	.285	.440	.655	.845
3	.100	.145	.220	.340	.500	.720
4	.115	.180	.255	.380	.545	—
5	.110	.180	.255	.405	.620	.840
6	.115	.165	.250	.390	.585	—
7	.120	.180	.270	.410	.625	.890
8	.105	.155	.260	.405	.610	.825
9	.115	.170	.245	.365	.520	.710
10	.105	.155	.235	.350	.510	.715
Ave.	.110	.165	.250	.380	.565	.780
Max.	.125	.190	.285	.440	.655	.890
Min.	.095	.145	.220	.335	.480	.675

SEPTAL COUNT

Specimen \ Volution	1	2	3	4	5	6
1	13	17	19	21	25	23
2	11	16	19	20	23	24
3	15	17	18	19	20	21
4	14	17	19	22	24	23
5	12	15	17	22	21	22
6	12	16	19	20	25	22
7	11	15	16	21	22	21
8	12	15	20	23	20	24
9	—	17	16	18	23	22
10	13	15	20	20	22	24
Ave.	12	16	18	21	23	23
Max.	15	17	20	24	25	25
Min.	11	14	15	17	20	21

HEIGHT OF VOLUTION (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6
1	.038	.050	.080	.116	.157	.200
2	.038	.070	.075	.146	.215	.240
3	.040	.056	.077	.118	.157	.192
4	.034	.054	.103	.145	.208	.205
5	.040	.064	.095	.132	.222	.255
6	.039	.052	.083	.140	.190	—
7	.040	.052	.072	.116	.165	.220
8	.038	.050	.070	.116	.148	.195
9	.030	.043	.076	.111	.157	—
10	.044	.067	.095	.152	.217	—
Ave.	.038	.056	.082	.129	.184	.215
Max.	.044	.070	.103	.152	.222	.255
Min.	.030	.043	.070	.111	.148	.192

Septa.—Septal furrows generally broadly sinuous, rarely straight; free margins of septa are weakly fluted across the middle of the shell; although not in contact, the septal loops are regularly opposed. The septal folds near the polar extremities are irregular, blister-like structures, the loops of one septum not being in regular apposition with those of the adjacent septum. Septal pores are apparent in but few specimens, and then in only the last two volutions of mature shells.

Character of wall.—The wall consists of tectum and keriotheca. The tectum is thin, averaging between 5 and 8 microns in thickness in the fifth and sixth volutions. It appears to remain about the same thickness in all volutions, but this apparent uniformity may be due to the difficulty of making such a small measurement accurately. The keriotheca averages from about 35 to 50 microns in thickness in the fifth and sixth volutions. The keriotheca appears to be the more variable element of the wall, but the apparent greater variability may be due to the fact that the keriotheca is much thicker than the tectum, and its variations are more easily measured. The keriotheca appears to be moderately coarse textured, as compared with *T. irregularis*, for instance, but this may merely be due to the better shell preservation of *T. tenuis*.

Chomata.—The chomata in this species are fairly well developed. They are rather high in relation to their length in most specimens, but tend to vary considerably in shape. In general, they are not as broad as chomata of *T. irregularis*. They are absent only on the last volution.

Tunnel.—The tunnel is irregular and tends to widen in successive volutions. It occupies about one half the height of volution.

Discussion.—This species is common in the Wyandotte formation and is one of the forms previously classed with *Triticites irregularis*. It differs from *T. irregularis*, however, in the following characters: *T. tenuis* is moderately and regularly fluted across the middle of the shell while *T. irregularis* is not. *T. tenuis* has a smaller half-diameter per volution and slightly smaller height of volution. The chomata in this species are, in general, not as broad as those in *T. irregularis*. In external size and shape, however, the two are distinguishable. This species is also quite similar to *T. ohioensis* (Thompson, 1936) in external size and shape but differs in several internal characters. It differs from *T. ohioensis* in having from 3 to 10 less septa in the sixth volution; in having a greater height of volution except in the sixth volution where the two are about the same; and in having a considerably thicker wall. Thompson states (ibid. p. 681) that *T. ohioensis* closely resembles *T. irregularis* from the Winterset in degree of septal fluting. Thus, *T. ohioensis* probably exhibits less fluting across the middle of the shell than does *T. tenuis*. It is impossible to compare this character in the two shells, directly, as Thompson figures no tangential

WALL THICKNESS (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6
1	.013	.016	.020	.025	.042	.053
2	.013	.015	.018	.025	.030	.050
3	.011	.015	.024	.035	.047	.050
4	.012	.015	.020	.027	.060	.065
5	.010	.013	.017	.028	.032	—
6	.010	.014	.018	.030	.050	.055
7	.010	.015	.018	.030	.040	.060
8	.013	.015	.017	.027	.037	.057
9	.013	.016	.022	.037	.057	.060
10	.013	.015	.018	.036	.046	.058
Ave.	.012	.015	.019	.030	.044	.056
Max.	.013	.016	.024	.037	.060	.065
Min.	.010	.013	.017	.025	.030	.050

TUNNEL ANGLE (DEGREES)

Specimen \ Volution	1	2	3	4	5
1	19	26	37	51	52
2	18	20	32	41	53
3	15	20	—	41	50
4	16	24	30	37	46
5	17	28	35	49	53
6	19	27	31	48	53
7	14	19	30	36	51
8	17	22	31	34	48
9	15	22	31	41	62
10	18	20	39	44	60
Ave.	17	24	33	43	53
Max.	19	29	39	51	62
Min.	14	19	30	34	46

sections of *T. ohioensis*. *T. tenuis* may be distinguished from *T. neglectus* Newell and *T. osagensis* Newell, both occurring in the Stanton formation, by being considerably less intensely fluted.

Occurrence.—The described specimens of this species were collected from the Island Creek shale of the Wyandotte formation, 0.2 miles east of the northwest corner of sec. 19, T. 16 S., R. 25 E., Miami County, Kansas.

Types.—Holotype—Type number 1118-A 1. Figured paratypes—Type numbers 3363-B 1 and 3363-C 1. Repository—University of Kansas.

TRITICITES cf. OSAGENSIS
Newell, 1934
Plate 69, figures 7–9

Triticites osagensis NEWELL, *1934*, Jour. Paleontology, vol. 8, no. 4, pp. 423, pl. 52, figs. 4a–f, pl. 53, fig. 4.

Shape.—This shell is elongate, slender, sub-cylindrical with rather blunt ends. The ends of some specimens are slightly constricted and irregular.

Number of volutions.—Mature individuals have from 6 to 7.5 volutions. A few specimens were observed having 8. Of the 24 specimens available, 15 of them had 7 or 7½ volutions, and 9 of them had 6 or 6½ volutions.

DIMENSIONS OF SPECIMENS OF T. CF. OSAGENSIS

Specimen[1]		*Half length* (mm)	*Form ratio*	*Diam. of proloculum* (mm)
1		5.0	5.6	.132
2		4.9	5.4	.119
3		4.1	4.6	.128
4		4.3	4.8	.126
5		3.9	4.6	.120
6		4.6	5.1	.126
7		5.0	5.0	.125
8		4.6	5.2	.128
9		4.8	5.1	.126
10		5.2	5.0	.142
6	Ave.	4.1	5.0	Ave. .126
Vol.	Max.	4.3	5.5	Max. .142
	Min.	3.9	4.6	Min. .119
7	Ave.	4.8	5.1	
Vol.	Max.	5.2	5.2	
	Min.	4.6	5.0	

[1] Since in this species there are about as many specimens having 6 volutions as those having 7, measurements of the half length and form ratio are given for both. Specimens 1 to 5 are shells of 6 volutions, and from 6 to 10, shells of 7 volutions. The average, maximum and minimum are also given for both.

RADIUS VECTOR (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6	7
1	.130	.185	.270	.405	.590	.785	—
2	.135	.185	.290	.415	.620	.860	—
3	.125	.180	.265	.375	.560	.770	.955
4	.105	.155	.230	.350	.535	.720	.940
5	.105	.165	.250	.380	.560	.735	—
6	.130	.180	.260	.350	.510	.690	.895
7	.120	.175	.255	.375	.550	.745	.955
8	.145	.205	.290	.390	.600	.830	—
9	.125	.175	.250	.370	.510	.765	—
10	.120	.170	.260	.380	.570	.760	—
Ave.	.124	.178	.262	.379	.561	.766	.936
Max.	.145	.205	.290	.415	.620	.860	.955
Min.	.105	.155	.230	.350	.510	.690	.895

Septa.—The septa in this species are quite strongly fluted, even across the middle of the shell. The fluting extends more than half way from the free margin of the septa. Along the free margin, the loops of adjacent septa are opposed and in contact. The fluting is regular all across the length of the shell except at the extreme poles where the chamberlets become somewhat irregular in shape and size. Septal pores are quite numerous in the last two volutions, appearing as a veritable meshwork in one specimen.

Character of wall.—The wall consists of tectum and keriotheca. The tectum is about

SEPTAL COUNT

Specimen \ Volution	1	2	3	4	5	6	7
1	13	19	21	26	25	27	—
2	14	18	22	27	27	29	—
3	12	17	20	23	23	27	29
4	12	18	21	22	29	28	26
5	14	17	22	28	25	26	24
6	14	17	21	23	24	26	—
7	15	21	22	25	28	30	—
8	14	19	21	23	24	26	—
9	13	16	19	22	25	25	—
10	15	19	21	23	22	30	26
Ave.	14	18	21	24	25	27	27
Max.	15	21	22	28	29	30	29
Min.	12	16	19	22	22	25	24

HEIGHT OF VOLUTION (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6	7
1	.046	.052	.085	.135	.185	.200	—
2	.045	.050	.105	.125	.205	.245	—
3	.040	.055	.082	.110	.185	.205	—
4	.040	.050	.075	.120	.185	.190	.220
5	.035	.055	.090	.130	.180	.180	—
6	.040	.052	.080	.090	.160	.160	.185
7	.038	.057	.080	.120	.175	.195	.205
8	.055	.060	.085	.105	.210	.230	—
9	.045	.050	.090	.120	.185	—	—
10	.040	.050	.070	.120	.160	.230	—
Ave.	.042	.053	.084	.118	.183	.213	.203
Max.	.055	.060	.105	.135	.210	.245	.220
Min.	.035	.050	.070	.090	.160	.160	.185

6 microns and the keriotheca from 45 to 60 microns in thickness in the sixth and seventh volutions. The tectum appears to remain about the same thickness throughout the shell, while the keriotheca appears to be the element of variable thickness in the wall.

Discussion.—This species is very similar in almost all characters to *Triticites osagensis* Newell, from the Stanton formation of Oklahoma. The two are strikingly similar in the intensity of septal fluting, such fluting being very rare in Missourian fusulinids.

WALL THICKNESS (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6	7
1	.012	.016	.020	.035	.057	.065	—
2	.009	.012	.020	.025	.050	.065	—
3	.010	.015	.018	.028	.040	.055	.070
4	.010	.011	.015	.025	.035	.050	.055
5	.009	.013	.020	.025	.050	.050	—
6	.010	.013	.020	.023	.035	.050	.065
7	.010	.013	.016	.025	.035	.050	.060
8	.011	.013	.016	.023	.045	.055	—
9	.011	.012	.018	.025	.035	.060	—
10	.010	.012	.012	.022	.030	.050	—
Ave.	.010	.013	.018	.026	.041	.055	.062
Max.	.012	.016	.020	.035	.057	.065	.070
Min.	.009	.011	.012	.022	.030	.050	.055

However, this apparent difference in the variability of the two wall layers may be due to the difficulty in measuring the exact thickness of the tectum. The texture of the keriotheca is moderately coarse in relation to the other triticites studied.

However, the forms from the two horizons appear to differ in some respects. Typical *T. osagensis* apparently has a smaller proloculum than the Farley limestone form. In this connection, some specimens of typical *T. osagensis* were restudied, and the proloculi measured varied between 0.070 mm and 0.120 mm in diameter, while the proloculi of the Farley form range from 0.119 mm to 0.142 mm in diameter. Also, there is apparently an abrupt thickening of the wall of typical *T. osagensis* after the fifth volution. Such is not true of the Farley limestone form, as can be readily seen by referring to the table showing the wall thickness per

TUNNEL ANGLE (DEGREES)

Specimen \ Volution	1	2	3	4	5	6
1	16	17	31	35	36	55
2	12	18	23	32	42	—
3	15	20	27	35	48	—
4	17	20	29	42	54	—
5	17	19	24	28	34	66
6	16	16	30	42	56	—
7	20	18	25	32	35	49
8	13	19	24	42	42	—
9	18	20	31	37	50	—
10	15	22	34	35	52	—
Ave.	16	19	28	36	45	57
Max.	20	22	34	42	56	66
Min.	12	16	23	32	35	49

Chomata.—In the outer volutions the chomata are relatively narrow and high, but in the inner volutions they are broader in relation to their height. They are absent only in the last volution.

Tunnel.—The tunnel is rather irregular and tends to widen in successive volutions. It usually occupies less than one half the height of the volution.

volution. However, since typical *T. osagensis* was not studied in a statistical manner, it is impossible to make a direct, accurate comparison, and, consequently, on the evidence available the form from the Farley limestone is not deserving of separate specific rank.

Occurrence.—The specimens studied were collected from a thin shale parting and from the limestone itself, about one foot above the base of the Farley limestone at the Union Pacific railroad quarry at Loring, Kansas. The collections were made by R. P. Keroher and N. D. Newell.

Hypotypes.—Type numbers 3548, 3548 and 3548. Repository—University of Kansas.

TRITICITES PLICATULUS Merchant and Keroher, n. sp.

Plate 69, figures 13–15.

Shape.—The shape of this shell is subcylindrical with broadly rounded ends. The polar extremities exhibit irregular growth due to the crowding septal folds at the extreme ends of the last volution.

Number of volutions.—Mature individuals have, on the average, from 7 to 8 volutions, rare specimens attaining 9.

Only eight specimens were in such a condition that the half length and form ratio could be measured. The measurement for these characters are from shells having approximately 7 volumes.

Septa.—The septal furrows are broadly arcuate. The fluting in this species is more intense than that in any other described Missourian triticite. The loops along the free margin of a septum are in contact with the loops of an adjacent septum even across the middle of the volution. Except near the middle, however, the loops are rather irregular, and are more so in the end zones of the last two volutions. The fluting extends about half way up from the free margins of the septa. Septal pores are large but apparently very rare.

Character of wall.—The wall consists of tectum and keriotheca. The tectum ranges from about 7 to 10 microns in thickness and appears to remain about the same in all volutions; such may not be true, however, since the thickness of the tectum cannot be measured accurately in the inner volutions. The keriotheca ranges in thickness from about 30 to 45 microns in the sixth and seventh volutions. The keriotheca appears to have a moderately coarse texture.

Chomata.—The chomata in this species are quite weak for a triticite. Generally they occupy less than half the height of the volution. They vary considerably in shape, but in general, they are high in relation to their breadth. They are very feebly de-

MEASUREMENTS

Specimen	*Half length* (mm)	*Form ratio*	*Diam. of proloculum* (mm)
1	6.1	—	.126
2	4.4	4.1	.126
3	5.3	4.9	.142
4	4.0	4.4	.115
5	5.4	4.6	.134
6	5.1	4.8	.142
7	5.3	4.3	.126
8	5.2	4.3	.122
9	—	—	.118
10	—	—	.142
Ave.	5.1	4.5	.129
Max.	6.1	4.9	.142
Min.	4.0	4.1	.115

RADIUS VECTOR (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6	7
1	.130	.195	.290	.450	.645	.905	1.140
2	.150	.250	.315	.460	.655	.840	1.090
3	.115	.165	.260	.385	.585	.825	—
4	.140	.195	.260	.355	.460	.645	.890
5	.125	.175	.265	.390	.565	.820	—
6	.140	.195	.280	.390	.510	.710	.920
7	.115	.170	.250	.355	.510	.740	—
8	.105	.155	.240	.340	.510	.740	—
Ave.	.128	.182	.270	.390	.555	.778	1.010
Max.	.150	.205	.315	.460	.655	.905	1.140
Min.	.105	.155	.240	.340	.460	.645	.890

SEPTAL COUNT

Specimen \ Volution	1	2	3	4	5	6	7
1	11	18	20	23	25	24	28
2	12	19	20	24	28	28	—
3	11	18	20	22	25	28	—
4	13	18	24	29	29	32	34
5	12	17	20	23	24	26	28
6	12	20	18	23	23	25	—
7	11	18	22	25	29	30	35
8	12	17	20	25	27	26	27
9	13	17	20	24	26	27	30
10	13	19	24	29	27	29	—
Ave.	12	18	21	25	26	28	30
Max.	13	20	24	29	29	30	35
Min.	11	17	18	22	23	24	27

HEIGHT OF VOLUTION (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6	7
1	.040	.050	.100	.120	.195	.230	—
2	.040	.055	.060	.095	.100	.185	.240
3	.035	.050	.085	.125	.190	.250	—
4	.045	.055	.110	.145	.195	.200	.230
5	.045	.060	.080	.110	.120	.200	.230
6	.040	.055	.080	.100	.155	.230	—
7	.050	.050	.085	.105	.170	.230	.250
8	.042	.060	.095	.160	.200	.260	.240
Ave.	.040	.054	.087	.120	.166	.223	.236
Max.	.045	.060	.110	.160	.200	.260	.250
Min.	.030	.050	.060	.095	.100	.185	.210

veloped in the penultimate volution and absent in the last. Due to the intensity of the septal fluting and the small size of the chomata, it is often difficult to determine whether or not chomata are actually present in the outer three volutions.

Tunnel.—The tunnel is very irregular and low, as observed at the middle of several septa. It occupies only about one third of the height of the volution.

Discussion.—This species, occurring in the Plattsburg formation, is quite unusual considering its stratigraphic position. It is distinguished by its large size and intense septal fluting. *Triticites plicatulus* is somewhat similar to *Triticites secalicus*, which was identified by Dunbar and Condra (1927 p. 108) in the Plattsburg. However, topotype specimens of typical *T. secalicus* were available for study, and after a direct com-

WALL THICKNESS (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6	7
1	.012	.015	.018	.025	.035	.045	.055
2	.012	.014	.018	.020	.030	.040	.055
3	.010	.012	.018	.030	.040	.045	—
4	.010	.014	.016	.025	.035	.040	.045
5	.012	.015	.020	.030	.040	.045	—
6	.010	.015	.020	.025	.030	.035	.045
7	.010	.015	.018	.020	.030	.045	—
8	.009	.013	.020	.025	.035	.050	—
9	.013	.018	.020	.030	.045	.050	—
Ave.	.010	.014	.018	.026	.036	.044	.050
Max.	.013	.018	.020	.030	.045	.050	.055
Min.	.009	.012	.016	.020	.030	.035	.045

TUNNEL ANGLE (DEGREES)

Specimen \ Volution	1	2	3	4	5	6
1	16	18	25	39	30	50
2	15	18	26	28	45	—
3	18	22	24	28	49	45
4	19	18	24	33	54	49
5	17	20	23	26	39	33
6	17	18	22	30	46	60
7	13	17	25	33	43	39
8	16	21	43	38	42	—
Ave.	16	19	24	32	44	46
Max.	19	22	43	39	54	60
Min.	13	17	22	26	30	33

parison the two species were found to differ in the following respects: the septal fluting of *T. plicatulus* is markedly more intense than that of *T. secalicus*. *T. plicatulus* is somewhat less inflated than typical *T. secalicus*, the former having a form ratio ranging between 1:4.1 and 1:4.9 and the latter ranging between 1:2.5 and 1:3.7. Also, *T. plicatulus* apparently has a smaller half diameter per volution and thinner walls in the outer volutions. This species may be distinguished from all other fusulinids occurring in the Missouri subseries by either its distinctive size and shape or by the intensity of its septal fluting. From *Triticites cuchilloensis* occurring in the middle Magdalena limestone of New Mexico, it may be distinguished by its more intense septal fluting, smaller average form ratio, and greater height of volution after the third volution.

Occurrence.—The specimens on which this species is based occur in the Springhill limestone member of the Plattsburg formation. They were collected in the quarry at the crossing of U. S. highway 59 and the Santa Fe railroad, five miles southwest of Garnet, Kansas.

Types.—Holotype—Type number 6819-A 1. Figured paratypes—Type numbers 6819-B 1 and 6819-C 1. Repository—University of Kansas.

TRITICITES SECALICUS (Say) var. PRIMARIUS Merchant and Keroher, n. var.

Plate 69, figures 10–12, text figure 2–3

Triticites secalicus DUNBAR and CONDRA, *1927*, (*pars*) Nebraska Geol. Survey, Bull. 2, second series, pp. 104–108, pl. 7, figs. 1–7, pl. 8, fig. 6, pl. 11, fig. 7.

Shape.—The shape of this shell is elongate, fusiform with rather blunt ends. The ends are rather irregular in some specimens.

Number of volutions.—Mature individuals average from 6 to 6½ volutions, but some have as many as 7.5.

MEASUREMENTS

Specimen	*Half length* (mm)	*Form ratio*	*Diam. of proloculum* (mm)
1	4.8	4.2	.130
2	5.0	3.9	.145
3	4.7	3.9	.130
4	4.7	3.9	.151
5	4.5	4.1	.145
6	4.2	4.0	.158
7	4.7	4.4	.166
8	5.1	3.9	.142
9	4.5	4.1	.166
10	5.1	4.6	.153
Ave.	4.7	1:4.1	.149
Max.	5.1	1:4.6	.166
Min.	4.5	1:3.9	.130

The measurement of the half diameter and form ratio were taken from individuals of plus or minus 6 volutions.

Septa.—The septal furrows in this species are broadly arcuate. The septa are almost plane across the middle of the shell with free margins showing very weak but definite undulations in some specimens. They become moderately and irregularly fluted toward the extremities. No septal pores are apparent in the inner volution, but in the sixth volution they become very numerous and quite large and are present along the middle of the shell as well as in the polar zones.

Character of wall.—The wall consists of tectum and keriotheca. The tectum is thin,

RADIUS VECTOR (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6
1	.130	.215	.365	.530	.765	—
2	.165	.265	.400	.580	.850	1.120
3	.145	.225	.320	.480	.690	.960
4	.150	.245	.385	.560	.770	1.130
5	.155	.245	.370	.555	.805	1.130
6	.165	.265	.380	.570	.810	1.120
7	.170	.275	.405	.575	.775	—
8	.170	.255	.380	.565	.785	1.155
9	.165	.250	.355	.505	.690	1.005
10	.160	.250	.370	.530	.755	—
Ave.	.158	.247	.373	.545	.770	1.090
Max.	.170	.275	.405	.580	.850	1.155
Min.	.130	.215	.320	.480	.690	.960

SEPTAL COUNT

Specimen \ Volution	1	2	3	4	5	6
1	12	17	20	21	21	23
2	13	15	21	20	23	22
3	13	16	20	21	22	22
4	10	16	19	19	21	23
5	14	19	20	23	24	27
6	14	20	23	22	23	23
7	10	16	19	20	21	—
8	10	16	18	17	18	19
9	10	17	21	19	—	25
10	12	18	18	19	17	—
Ave.	12	17	20	20	21	23
Max.	14	20	23	23	24	27
Min.	10	15	18	17	17	19

HEIGHT OF VOLUTION (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6
1	.045	.085	.150	.175	.240	—
2	.060	.090	.110	.160	.225	—
3	.060	.080	.105	.155	.165	.245
4	.060	.095	.155	—	—	—
5	.060	.085	.125	.180	.220	.270
6	.060	.095	.130	.170	.200	—
7	.065	.100	.115	.185	.240	—
8	.055	.090	.140	.175	.210	.285
9	.060	.090	.125	.185	.250	—
10	.050	.075	.100	.160	.210	.270
Ave.	.058	.091	.126	.170	.220	.265
Max.	.065	.100	.155	.185	.250	.285
Min.	.045	.075	.100	.155	.165	.245

averaging about 5 or 6 microns, and appears to remain about the same in all volutions. The keriotheca averages about 58 microns in thickness in the fifth volution and about 70 in the sixth. The keriotheca appears to be quite coarse in texture, relative to the other Missourian triticites. The lamellae in some of the specimens are quite easily distinguished. In Dunbar and Condra's description of *Triticites secalicus*, they state that the texture of the keriotheca is moderately fine. The difference between

their description and this may be due to a difference in preservation of the shells from the two horizons, or it may be merely a difference in the standard of comparison.

Stanton with typical *Triticites secalicus* from the Oread formation, topotype material of the typical form was obtained and studied. The two forms are almost exactly

WALL THICKNESS (MILLIMETERS)

Specimen \ Volution	1	2	3	4	5	6
1	.012	.028	.032	.045	.065	—
2	.012	.025	.032	.045	.070	.090
3	.011	.020	.027	.040	.065	—
4	.015	.021	.033	.045	.070	.075
5	.011	.028	.035	.045	.065	.065
6	.013	.018	.030	.050	.063	—
7	.013	.027	.035	.055	.065	—
8	.015	.022	.030	.050	.055	—
9	.012	.019	.025	.050	.055	.070
10	.010	.018	.030	.050	.070	—
Ave.	.013	.023	.031	.048	.064	.075
Max.	.015	.028	.035	.055	.070	.090
Min.	.011	.018	.025	.040	.055	.065

Chomata.—The chomata in this species are rather weak, occupying, in general, between one-third and one-half the height of volution. They are irregular in shape, but tend to be broader than they are high. They are often very small in the fifth volution and are generally absent in the sixth volution. The chomata in this species are quite comparable to those in *T. plicatulus* from the Springhill limestone.

alike in most of the characters but persistently differ in a few. Perhaps the greatest difference is in shape. Typical *T. secalicus* appears to be a little more inflated than the variety from the Stanton. The typical form has a form ratio varying between 1:2.5 and 1:3.7, while the Stanton form varies between 1:3.9 and 1:4.6. Typical *T. secalicus* also has a somewhat greater average radius vector per volution and height of volution

TUNNEL ANGLE (DEGREES)

Specimen \ Volution	1	2	3	4	5
1	24	26	34	47	58
2	21	31	37	55	64
3	22	38	38	50	51
4	22	25	26	47	50
5	24	34	48	53	63
6	24	30	43	58	—
7	25	32	32	50	—
8	28	29	37	50	64
9	24	33	48	54	—
10	24	25	40	59	68
Ave.	23	30	38	52	59
Max.	28	37	48	59	68
Min.	21	25	26	47	50

Tunnel.—Tunnel is considerably more regular than that in the other forms described. It generally occupies a little more than one-half the height of the volution.

Discussion.—In order to make a direct comparison of this variety occurring in the

than the Stanton variety. In all the other characters the two forms are alike. One striking similarity is that both forms have the same abundance of septal pores in the outer volutions. *T. secalicus primarius* is evidently more primitive in shape but

is closely related to typical *T. secalicus*.

Occurrence.—This species was collected from the top of the Stoner member of the Stanton formation in the center of the west side of sec. 31, T. 26 S., R. 15 E, Woodson County, Kansas.

Types.—Holotype—Type number 20840. Figured paratypes—Type numbers 20841 and 20842. Free specimens—Lot number 585. Repository—University of Wisconsin.

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JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 6, PP. 615–616, 1 TEXT FIG., NOV., 1939

SHALLOW PLEISTOCENE MARINE SHELL STRATUM IN LIVINGSTONE PARISH, LOUISIANA

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THE COASTAL portion of the Florida parishes of Louisiana has been considered to be unfossiliferous. Recently Fisk (1938) referred this area to the coastwise surface of the Port Hickey terrace. The Pleistocene sediments in this area have been considered by most geologists to have been formed under deltaic conditions. It is the purpose of this note, therefore, to point out that shallow borings in the neighborhood of Springville, Ts. 6 and 7 S., R. 5 E., encountered both marine and brackish-water

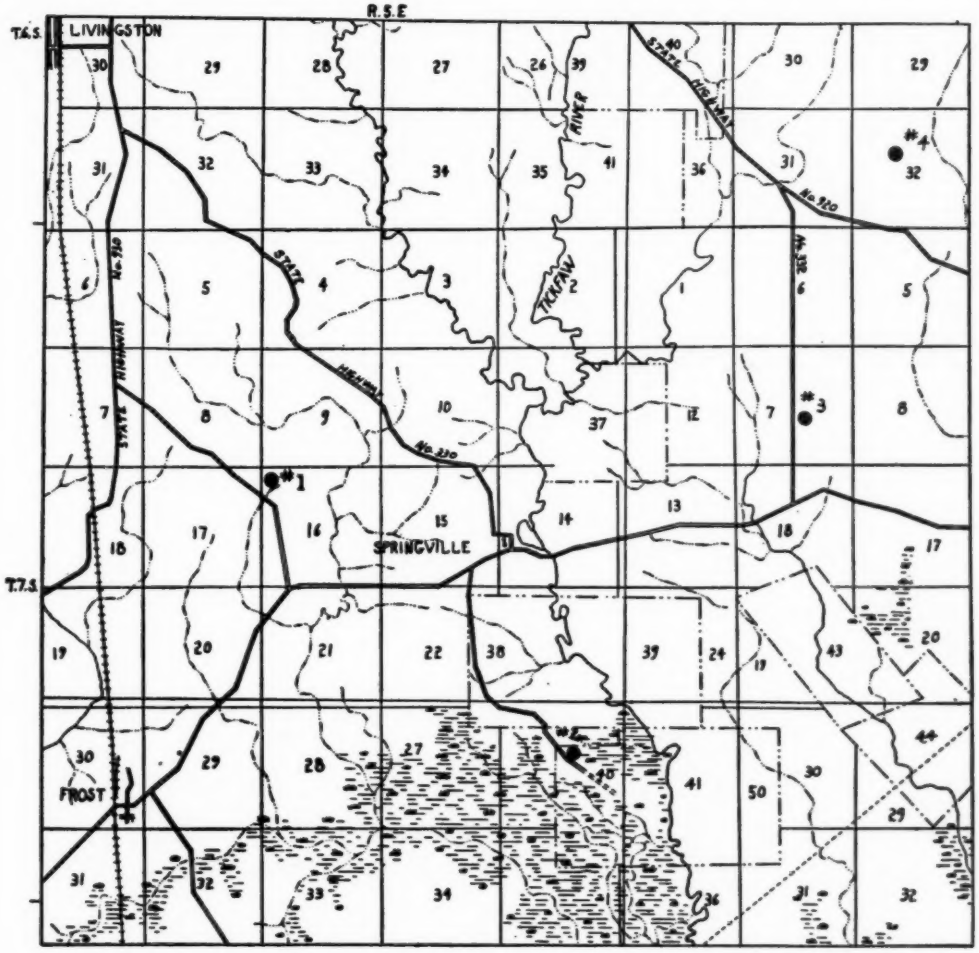

FIG. 1.—Index map of part of Louisiana showing location of four core holes in which marine and brackish-water faunas were encountered at depths of less than 300 feet.

faunas at a depth of less than 300 feet. It is not known how extensive these marine and brackish-water shell beds are, but they may be as extensive as some brackish-water faunas recorded by Dr. Horace G. Richards (1938) from a depth of 206 feet in a well at the Louisiana State University dairy barns. Similar shells were encountered in a shallow water well drilled on the greater University Land Company tract in sec. 49, T. 7 S., R. 1 E., in the eastern edge of the university oil field. It, therefore, appears probable that an extensive area of the Port Hickey sediments carries marine lenses, though the terrace appears continental at the surface.

The following data were derived from four core holes whose approximate locations are shown on the accompanying map. The stratum carrying the fauna is composed of a dark-gray silty clay. The fossils encountered in these holes are listed briefly as:

HOLE NO. 1: Clams—*Arca* sp. (common), *Mulinia* sp. Snails—*Drillia* sp., *Oliva* sp.; Corals—*Astrangia* sp. Bryozoa—At least six genera. Foraminifera—*Cibicides* sp., *Elphidium gunteri* var. *galvestonensis*, *Elphidium* sp., *Quinqueloculina costata?*, *Quinqueloculina* sp. A, *Quinqueloculina* sp. B, *Quinqueloculina* sp. C, *Rotalia beccarii* var. *parkensoniana*, *Rotalia beccarii* var. *tepida*, *Triloculina oblonga*. Ostracods—*Bairdia* sp., *Bythocypris* sp., *Cytherelloidea?*, *Cytheridea* sp. A, *Cytheridea* sp. B, *Cytheridea* sp. C, *Loxoconcha* sp., *Microcythere* sp., *Xestolebris* sp. A, *Xestolebris* sp. B, seven unnamed genera.

HOLE NO. 2: *Balanus* sp. (a barnacle), *Ostrea virginica*.

HOLE NO. 3: Clams—*Mulinia* sp., *Phacoides* sp. A (common), *Phacoides* sp. B. Snails—*Oliva?* sp., *Terebra* sp. Foraminifera—*Elphidium gunteri*, *Rotalia beccarii* var. *parkensoniana*, *Rotalia beccarii* var. *tepida*.

HOLE NO. 4: Only a trace of macrofossil shell fragments.

Hole NO. 2 was not drilled deep enough to strike the marine stratum, and there was no evidence to indicate any correlation between the brackish-water oyster deposit and the marine clay. The fossils in hole no. 4. were at very shallow depths and so badly broken and leached that no generic identification could be made.

The material for this note was discussed with Dr. H. V. Howe, Louisiana State University. The author also wishes to express gratitude to the Messrs. Carroll Cook, W. C. Blackburn, and James White, of the geological department of the Humble Oil and Refining Co., for help in obtaining samples and for permission to use portions of their field data.

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JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 6, PP. 617–620, 1 TEXT FIG., NOV., 1939

CONVEXITY OF ARTICULATE BRACHIOPODS AS AN AID IN IDENTIFICATION

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ABSTRACT—Attention is called to the importance of general convexity in the taxonomy of brachiopods. The classification of different types of convexity in brachiopods is discussed, and the probable phylogeny of some types is suggested. A key for the identification of certain brachiopod groups is included.

FOR MANY YEARS in teaching Invertebrate Paleontology, difficulties have been encountered in training students to distinguish between brachiopod families. Larger taxonomic units generally are based on internal structures and the time and skill necessary for the correct interpretation of brachiopod interiors are generally too great for the average student. When a specimen is poorly preserved or the two valves are in close contact, examination of internal structures may be impossible. The author has made an effort to correlate internal structures and external form with the idea of widening the base of interpretation so that the student could make better use of readily accessible external characters.

Convexity of the valves in brachiopods is one form characteristic that lends itself readily to analysis. In the past, investigators have recognized the value of shell convexity, but have not made full use of it.

In 1894, Hall and Clarke, in "An Introduction to Brachiopoda," used the term, *concavoconvex*, for those shells in which the ventral valve is convex, and the dorsal valve concave. In the same publication, these authors used the term, *resupinate*, and applied it to those forms in which the shell is concavo-convex in the umbonal region, but in later growth, the curvature is reversed, the ventral valve becoming concave and the dorsal valve convex. Examples of this are found in *Strophomena* and *Strophonella*. The above authors, however, do not always use the term resupinate as originally defined, and many authors apply this term to any form in which the dorsal valve is more convex than the ventral valve.

In 1932, Schuchert and Cooper in their publication, "Orthoidea and Pentameroidea," called attention to the abundance of biconvex brachiopods in which the longitudinal view shows that the ventral valve is slightly more convex than the dorsal valve. They used the term, *dorsibiconvex*, to describe those shells in which the dorsal valve is more convex than the ventral, *convexoconcave* for those in which the dorsal valve is convex and the ventral concave, and *pseudoresupinate* for those in which the shells are convexoconcave in the umbonal region and in later growth the dorsal valve becomes concave and the ventral convex. These various terms are used in the present paper in the same sense as defined by the above mentioned authors.

The writer suggests the term, *ventribiconvex*, to describe those shells in which the ventral valve is more convex than the dorsal; the term, *ventriconvex*, for those in which the ventral valve is convex and the dorsal valve flat; and the term, *dorsiconvex*, for those in which the dorsal valve is convex and the ventral flat. All the above mentioned types of convexity were examined in this study. The part these characters played in the phylogeny, as revealed by the ontogeny, points to two lines of evolution. In one, the ventral valve becomes progressively more convex, while the dorsal valve becomes less convex, then flat, concave, and finally resupinate. Some members do not evolve beyond the ventribiconvex stage, others reach the ventriconvex or the concavoconvex stage, while a few become resupinate in fully developed individuals. The family Dalmanellidae illustrates the ventriconvex stage. Chonetidae and some of the Strophomenidae have reached the concavoconvex stage while other Strophomenidae have reached the resupinate stage. The term,

ventritumid, is applied to those groups which have this progression of form stages.

In the other line of development, the dorsal valve becomes progressively more convex, while the ventral valve becomes less convex, flat, concave and pseudoresupinate. ontogeny of the several genera constituting many brachiopod families, as now conceived show that some of them contain these morphological equivalents.

Every member of a family must have a common phylogeny. A genus which has been

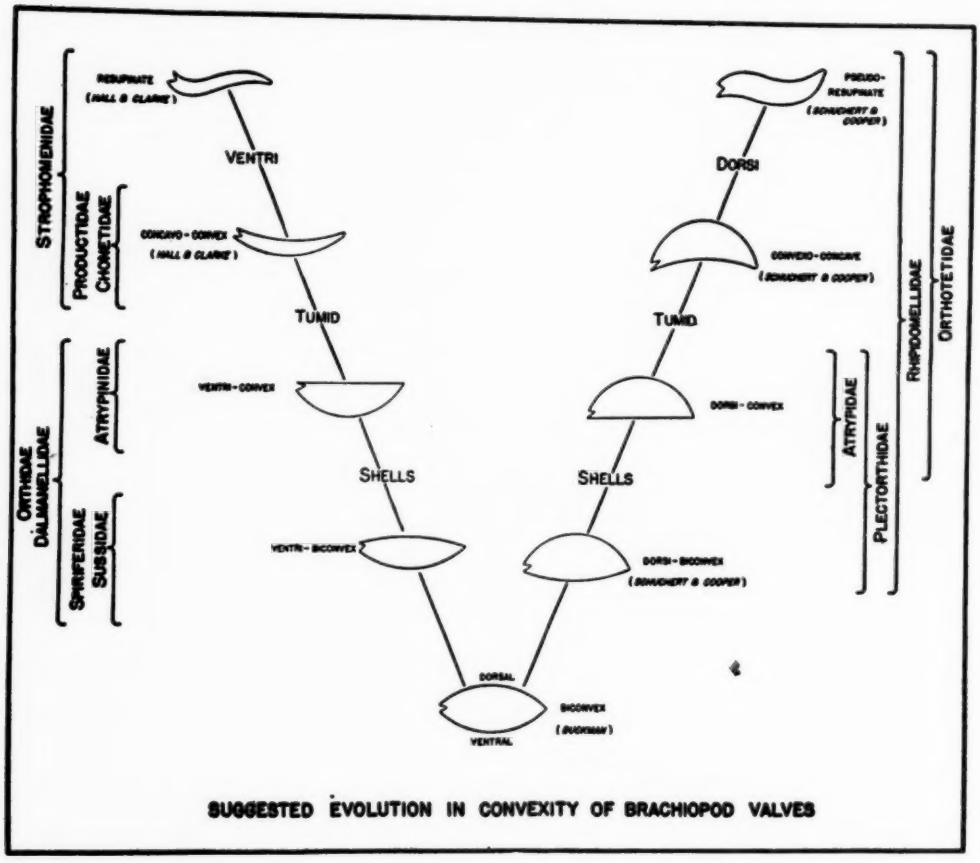

FIG. 1.—Suggested evolution in convexity of brachiopod valves.

Plectorthidae, Rhipidomellidae, and Orthotetidae illustrate this development. The term, *dorsitumid*, is used here to describe these shells.

It has long been known that many unrelated groups of organisms which evolved independently have a parallel development and consequently may possess common characteristics. These have been called morphological equivalents by Hyatt and homeomorphs by Buckman. A study of the ventritumid throughout its life history cannot be related to another genus which has had a dorsitumid ontogeny. If they have common characteristics, it must be that they have had some degree of parallelism in development.

If two lines of form development are established within a family then that family containing both dorsi tumid and ventritumid shells will have to be reorganized. However, the genera placed in individual

families as now classified generally agree as to relative convexity.

Both ventritumid and dorsitumid shells are represented in the group of genera forming the family, Orthidae Woodward. In the above mentioned publication by Schuchert and Cooper, these authors place these several genera under various families, separating them on the basis of internal and some external characters. *Orthis* and related forms are placed by them in the family Orthidae. *Orthis* is ventriconvex and a study of published discussions and illustrations shows that the shells forming this group are all ventritumid.

Plectorthis, *Platystrophia*, *Macewanella*, *Hebertella*, and *Orthostrophis* are placed in the family, Plectorthidae Schuchert and Cooper. These are dorsitumid throughout their life history and are in no way related to the emended Orthidae.

Dalmanella and related forms are ventritumid. They are placed by the above authors under the emended Dalmanellidae.

The genera listed under Strophomenidae King fall into two groups, one being ventritumid and the other dorsitumid throughout their life history. *Plectambonites*, *Rafinesquina*, and *Strophomena* are examples of the former, and *Derbya*, *Meekella*, and *Orthotetes* are examples of the latter. These two groups represent parallelism in development rather than close kinship. The family name, Strophomenidae, is emended to cover those genera which have a ventritumid development, and the family name, Orthotetidae, is applied to those which have a dorsitumid life history.

Another group made up of unrelated genera are those listed as belonging to the family, Atrypidae Gill. The genus, *Atrypa*, from which the family takes its name, is dorsitumid throughout its life history. Other genera such as *Atrypina* and *Zygospira* are ventritumid throughout their life history. The family name, Atrypidae, is retained for the dorsitumid forms and the family name Atrypinidae, is applied to the ventri-tumid group of genera.

All Spiriferidae studied were ventribiconvex or ventriconvex, except *Spirifer acuminata*, which is dorsibiconvex. It is likely that some reorganization of these spiriferoid forms will be necessary and undoubtedly other changes will be unavoidable after further study.

These relative convexities were more useful in an interpretation of Protremata than in Telotremata. In the latter order, the relative convexity seemed to be more useful in the broadly rostrate and long-hinged shells than in those which are narrowly rostrate. No dependable external characters were found for those families of Telotremata which are narrowly rostrate. However, only a very limited number of these were available for this study.

The results of this investigation have been embodied in the formulation of a key to Articulate brachiopods. Other important characters have been used in the key and found invaluable. The length of the hinge line or the absence of a hinge line; the width of the cardinal areas or absence of these areas; the cardinal process which may often be partially exposed when valves are in contact; the chilidium; the presence or absence of structures in the delthyrium; the perideltidial area; the presence or absence of a foramen were found useful.

Key to Articulate Brachiopoda

I. Delthyrium open or closed by deltidium. No brachial supports.....*Protremata*

A. Hinge line long or short.

1. Valves dorsitumid.

a. Dorsibiconvex to dorsiconvex.
Hinge line nearly or about equal to or longer than width across middle; delthyrium open; cardinal areas broad, subequal.....*Plectorthidae*

b. Dorsibiconvex or convexoconcave.
Delthyrium open or closed by short deltidium; hingeline shorter than width across middle. Areas subequal.....*Rhipidomellidae*

c. Dorsiconvex, convexoconcave, or pseudoresupinate.
Delthyrium closed by highly developed deltidium; hinge line shorter or longer than width across middle. Ventral cardinal area broad, dorsal cardinal area narrow or lost. Perideltidial area present.....*Orthotetidae*

2. Valves ventritumid.
   a. Valves ventriconvex.
      Hinge line about equal to width across middle or slightly shorter. Cardinal areas broad, subequal. Delthyrium open.
      1′. Exterior fascicostellate ..... *Dalmanellidae*
      2′. Exterior not fascicostellate ..... *Orthidae*
   b. Valves concavoconvex.
      Hinge line longer or slightly shorter than width across middle.
      1′. Cardinal areas narrow, subequal, delthyrium covered by convex or flat deltidium.
         a′. Without spines on cardinal margin..... *Strophomenidae* (in part)
         b′. With spines on cardinal margin ..... *Chonetidae*
      2′. Cardinal areas lost or almost lost.
         a′. Spines on one or both valves ..... *Productidae*
   c. Valves resupinate.
      Hinge line longer or slightly shorter than width across middle.
      1′. Cardinal areas narrow, subequal, delthyrium covered by flat or convex deltidium ..... *Strophomenidae* (in part)

B. Shells hemirostrate.
   1. Valves ventritumid.
      a. Valves ventriconvex or ventribiconvex.
         1′. Delthryium open.
            a′. Spondylium not supported by septum..... *Syntropidae*
            b′. Spondylium supported by septum..... *Porambonitidae*
         2′. Delthyrium covered by concave deltidium.
            a′. Spondylium supported by septum..... *Pentemeridae*

II. Delthyrium open, closed by deltidial plates, or filled with pseudodeltidium. Brachial supports. ..... *Telotremata*

A. Valves rostrate.
   1. Narrowly rostrate.
      a. Valves striate or plicate.
         1′. Brachial supports in form of loops..... *Rhynchonellidae*
         2′. Brachial supports in form of spiralia..... *Rhynchospiridae*
      b. Valves generally smooth.
         1′. Brachial supports in form of loops..... *Centronellidae, Terebratulidae, Terebratellidae*
         2′. Brachial supports in form of spiralia..... *Meristellidae, Athyridae*
   2. Broadly rostrate near 180°. Spiralia.
      a. Valves striate, plicate, lamellose or spinose.
         1′. Dorsibiconvex or dorsiconvex..... *Atrypidae*
         2′. Ventribiconvex or ventriconvex..... *Atrypinidae*

B. Valves with hinge line long or short. Spiralia.
   1. Valves ventritumid, ventribiconvex and ventri-convex.
      a. Shells not punctate..... *Spiriferidae* (in part)
      b. Shells punctate..... *Sussidae*

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PALEONTOLOGICAL NOTES

RUBBER CASTS AND MOLDS OF FOSSILS

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GOOD CASTS of complex fossil structures are in many instances difficult to make because of the lack of a suitable casting substance. Clay, and to a lesser extent gutta percha, generally cannot be extracted without distortion from complex portions and undercuts. Gelatin and similar substances lack the tensile strength needed, tear when extracted from some molds, and also lack desirable permanency.

Upon the suggestion of Dr. N. D. Newell, the writer undertook an examination of certain liquid rubbers on the market. Of these Airvulc Liquid Rubber was found most satisfactory. It is a black liquid which dries quickly at room temperature to form a very elastic and durable black rubber.

The object to be coated should be clean and dry. The rubber is sprayed or painted on in thin coats, the number of which depends on the size of the fossil and the thickness desired for the rubber impression. For small pelecypods 10 to 15 coats were generally used. In the first coat care should be taken to avoid the formation of air bubbles. It should dry one to two hours. Successive coats should dry one-half to one hour. A slight tendency to shrink in drying makes it advisable to apply partial coats into the undercuts and cavities of complex molds before the whole object is covered. The rubber does not adhere to fossil or matrix and is easily pulled off. No matter how great the distortion during removal, the rubber will resume the shape of the fossil.

The rubber has no grain, will reproduce extremely fine markings, and will bear great magnification. The black color is advantageous for photography and purposes of study, as fine markings become distinct after coating with ammonium chloride.

This method for securing artificial reproductions is of exceptional usefulness in production of artificial casts from natural molds of small mollusks, where details of ornamentation, dentition, and form can scarcely be reproduced by other methods.

Airvulc Liquid Rubber sells for about $6 per gallon, $1.65 per quart. It is produced by the Self-vulcanizing Rubber Co., 605 W. Washington Blvd., Chicago, Ill.

CHONETES BRAZOSENSIS, NEW NAME FOR *CHONETES FRAGILIS* KING

RALPH H. KING
University of Kansas, Lawrence, Kansas

Dr. Carl C. Branson has informed me that the name *Chonetes fragilis* was applied to a species from the Devonian Silica shale of Ohio by Grace Anne Stewart in 1927.[1] I was not aware of this prior use when I assigned the name to a Pennsylvanian species from Texas.[2] As the Pennsylvanian species must be given a new name, I propose to rename it *Chonetes brazosensis*, as it is found most commonly in the valley of Brazos River.

[1] *Ohio Geol. Survey, Bull.* 32, (1927), pp. 38–39, pl. 3, figs. 16–19.

[2] *Jour. Paleontology*, vol. 12, no. 3, (May, 1938), pp. 260–261, pl. 36, figs. 8–13.

NEW NAMES FOR OSTRACODE HOMONYMS

CURT TEICHERT
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In two recent publications which appeared in December 1937, I introduced the name *Basslerites* for a new genus of the family Beecherellidae.[1] As this name had been used by Howe in American Museum Novitates no. 956, published on November 1, 1937, I propose to replace it by the name *Rayella*, with *Basslerites hanseni* Teichert as the genotype.

[1] C. Teichert, *1937*. A new Ordovician fauna from Washington Land, North Greenland. *Meddelelser om Grønland*, vol. 119 no. 1.
——, *1937*. Ordovician and Silurian Faunas from Arctic Canada. *Fifth Thule Exped., Rep.* vol. 1 no. 5. Copenhagen.

Furthermore, in the first mentioned publication (p. 61) a new species *Bythocypris minuta* was established. This name, however, had been used before by F. Bouček (*Neures Jahrb.* Beilage-Bd. 76, Abt. B, p. 77, 1936) and it is therefore proposed to replace it by *Bythocypris bouceki*.

I am indebted to Drs. H. N. Coryell and Marshall G. Kay, of Columbia University, New York, for calling my attention to the fact that the above mentioned names were preoccupied.

USE OF THE NAME *MARGINULINA MEXICANA*

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Extension of the foraminiferal genus *Marginulina* to cover a wider variety of forms, as has been common practice in recent years, gives rise to difficulties in nomenclature. Use of the name *Marginulina mexicana* furnishes a very good example.

In the spring of 1925 Cushman (March–April, 1925) described a species from Eocene beds of Mexico as *Cristellaria mexicana*. During the fall of the same year he (October, 1925) described another species also from Mexico but from much younger beds, as *Marginulina mexicana*.

G. D. Hanna and C. C. Church (1937) later published an excellent note, in which *Cristellaria mexicana* Cushman, and forms related to it, were discussed. These writers introduced *Marginulina mexicana* (Cushman) to replace *Cristellaria mexicana* Cushman. Shortly afterward a paper by Garrett and Ellis (1937) appeared, in which a metatype of *Marginulina mexicana* Cushman was figured, and *M. mexicana* var. *vaginata*, n. var., was described. This variety is a valuable marker fossil in the Gulf Coast.

The classification of Hanna and Church appears to conform to Cushman's present usage. Therefore, *Marginulina mexicana* (Cushman) has priority over *M. mexicana* Cushman.

At present there is little uniformity among various workers as to the application of the genus *Marginulina*. Possibly in the future this may be rectified. At any rate, under the circumstances I believe confusion will be avoided by raising *M. vaginata* Garrett and Ellis to specific rank, thus leaving no conflict with *M. mexicana* (Cushman).

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HANNA, G. D., and CHURCH, C. C., *1937*, Notes on *Marginulina vacavillensis* (Hanna): *Jour. Paleontology*, vol. 11, no. 6, pp. 530–531.

[1] Published with the permission of the Stanolind Oil and Gas Company.

REVIEWS

GEOLOGY OF THE MARATHON REGION TEXAS, by Philip B. King: U. S. Geological Survey, Prof. Paper, 187, 1937; 148 pp. 24 pls. 33 figs.[1]

This very excellent and detailed paper represents the results of nearly seven years field work in one of the most interesting and complex areas of the southwest. The Marathon region is a structural dome located at the junction of the Edwards Plateau and the Mexican Highlands Province in southern trans-Pecos Texas. Here Paleozoic rocks ranging in age from Cambrian to Permian are exposed by a window in the Cretaceous. The pre-Permian rocks are strongly folded in Appalachian-type structures with unfolded Permian resting unconformably on them. Borings for oil have shown that the folds are connected, around the south and east sides of the Central Mineral Region of Texas, with the Ouachita folds of Oklahoma and Arkansas.

Most of the paper is occupied with a presentation of the early Paleozoic stratigraphy and structure. From the available data is reconstructed with admirable logic the history of the late Paleozoic mountain range which occupied the site. In early Paleozoic time the Marathon Region was a geosyncline in which were deposited great thicknesses of sediments derived from the old land mass of Llanoria to the south. The Upper Cambrian sediments consist largely of sandstones and flags. The Ordovician rocks are cherty shale and limestones 2,000 feet thick. They contain a fauna of graptolites, linguloid and oboloid brachiopods, pteropods and trilobites. They contrast strongly with the foreland facies of the same age in the El Paso region where the rocks are dolomites carrying orthoid brachiopods, cephalopods, corals and sponges. The paleogeographic conditions of Ordovician time are excellently illustrated by a block diagram (fig. 16) which shows very clearly the postulated relations of Llanoria, the clastic sediments of the geosyncline, and the dolomites and limestones of the foreland.

[1] Review published by permission of the Amerada Petroleum Corp.

Resting unconformably on the Ordovician are 200 feet to 600 feet of grey to white novaculite and chert, the Caballos. Fossils are extremely rare in these beds and give no definite indication of their age. On the basis of lithologic character and stratigraphic position these beds are correlated with the Arkansas novaculite and classified as Devonian?

Overlying the Caballos with notable unconformity is a great thickness of Pennsylvanian rocks reaching 12,000 feet in the south-eastern part of the area but thinning greatly to the northwest. These rocks are largely clastic, being the debris deposited in the geosyncline from the erosion of the rapidly rising Llanoria during the Marathon orogeny. These clastics may be divided into two types, the older finer deposits and the younger coarser deposits or, in the language of the alpine geologists, the Flysch and the Molasse. The Molasse phase includes the well-known boulder beds whose origin has been widely discussed. The boulders are of enormous size, reaching 130 feet in diameter. They are composed of fragments from all older formations of the region including some Pennsylvanian limestones unlike any now exposed there and are fairly well arranged along bedding planes. King suggests that these boulders were brought from some distant point as parts of overthrust slices and carried into their present position by mud flows on the slopes of the rising mountains.

The process by which the Pennsylvanian and older rocks were raised into lofty alpine chains is beautifully illustrated in plate 20 by a series of block diagrams showing five stages in the development of the major structural features of the region. These diagrams, together with the diagram of the paleogeography of the Ordovician, give a very clear picture of the sedimentation and structural history of the region.

The total crustal shortening caused by the orogeny is about two to one. This shortening was accomplished about equally by folding and thrusting. There are at least two major overthrusts and innumerable smaller ones.

After the orogeny, which was essentially complete by the end of Pennsylvanian time, came the planation of the mountains and the advance of the Permian sea over at least the northwestern portion of the folded belt. The Permian formations have been tilted but not folded so that their structure is comparatively simple. Their stratigraphy has been described by P. B. and R. E. King in University of Texas Bull. 3042, and the present treatment is somewhat abbreviated, although some important corrections and modifications have been made.

The lowest formation of the Permian is the Wolfcamp which is composed of clastics and limestones of considerable lateral extent. Overlying Permian rocks, however, are characterized by abrupt changes in facies which seem to be controlled by banks or reefs, probably largely of organic origin. The Leonard formation rests on the Wolfcamp unconformably and is largely siliceous shale containing a dolomitic member, the Hess, which was originally described by King as a separate formation but is now considered to be a facies of the Leonard, separated from the shale facies by a massive limestone bank. The overlying Word formation displays the same gradation from clastics to dolomite, although King states that the dolomite shows little evidence of reef origin.

In the next epoch reef growth reached its culmination in the deposition of the great semicircular Capitan reef some 1,800 feet thick, enclosing the Delaware Basin over one hundred miles in diameter and filled with several thousand feet of the clastic Delaware Mountain formation. Its regional relations are very well illustrated in a section and map (fig. 29).

The Tessey limestone is a presumably Permian formation overlying the Capitan and tentatively correlated with the Salado halite found in borings northeast of the Marathon region. The Triassic is only questionably represented by the Bissett limestone conglomerate.

The Cretaceous rocks are chiefly of the Comanche series which was deposited in an advancing sea gradually overlapping the ancient ridge formed by the positive area of the Glass Mountains on the early Mesozoic peneplane. There are beds of Upper Cretaceous age found in the extreme northwestern part of the region.

There is a very full discussion of the structural problems of the Marathon Basin, a briefer discussion of the post-Cretaceous structural and physical history, and a mention of the economic geology. To illustrate the development of the region, the paper contains, in addition to numerous smaller maps and diagrams, four excellent large folded maps. One is a general map and section of the Marathon uplift, another a map covering the pre-Permian area, the third a map showing structure sections of the same area, and finally a map of the Dugout Creek locality with sections showing the detailed relations of the largest thrust of the region.

Probably the chief value of this paper to the petroleum geologist is the key that it gives to the interpretation of the difficult stratigraphic problems encountered in subsurface work. Here we find worked out in thorough detail and illustrated clearly and beautifully many complex stratigraphic relations whose analogues appear in the subsurface where the evidence is not at hand to solve the problem completely. This is especially true in the problem of the relations of the Permian to the older rocks encountered in recent deep drilling. From the scientific point of view the greatest interest lies in the fact that here we have described the roots of a Paleozoic alpine chain apparently connected and perhaps contemporaneous with the Ouachitas. These ancient mountains continue to the southwest, reappear in the Solitario and possibly underlie the Cordilleran folds of northern Mexico. We seem to have here a remnant of an east-west trending Paleozoic geosyncline.

JOHN M. HILLS, Midland, Texas.

MIOCENE STRATIGRAPHY OF CALIFORNIA, by Robert M. Kleinpell: American Association of Petroleum Geologists, 1938; 450 pp., 18 charts, 13 figs.

Though it is an oft-told story, we may allow the appearance of Dr. Kleinpell's book to justify us in recalling the surprisingly rapid growth of Tertiary stratigraphy on the basis of foraminiferal paleontology. In 1920 scarcely anybody entitled to an opinion doubted the complete stratigraphic

worthlessness of the smaller *Foraminifera*. Five years later this conclusion was being challenged hopefully by several oil-company paleontologists, mostly untrained amateurs, who were already finding reasons to doubt its correctness. In that very year, however, Professor Diener reaffirmed the old belief and quoted in support of it one of "the best European authorities." By 1930 excellent correlations on the basis of small *Foraminifera* were being made all along the Gulf and Pacific coasts of the United States and Mexico, and even our European colleagues were beginning to wonder. In 1938 we have the appearance of this book in which, without apology, the author discusses fundamental stratigraphic problems and correlates numerous California formations on the basis of data that were despised a few years earlier. Truly, a remarkable revolution in geologic thought, so striking that 30 years more should allow some notion of it to penetrate into geological textbooks and elementary teaching.

Dr. Kleinpell began his study of California stratigraphy by examining a set of samples collected long previously by his brother from the beautiful exposures in Reliz Canyon, a locally famous place in the Salinas Valley. Owing to this accidental beginning, the author has acquired the habit of writing as if, after all, he were merely classifying the finer-grained rocks exposed along that canyon. The present reviewer had to work hard to keep that idea out of the title of the volume. Obviously the book has far outgrown any such limits, though already one reviewer has failed to notice the fact.

For one thing, Dr. Kleinpell has one of the best discussions of stages and zones and their uses that is to be found anywhere. His several quotations from Oppel's classic volume are very welcome, and so are his own statements. For another, he classifies nearly all the good Miocene sections in California and not merely the one in Reliz Canyon. For still another, he discusses foraminiferal ecology at length and also draws many conclusions as to the succession of tectonic, volcanic, and other events during the California Miocene. And finally, as paleontologists will note with pleasure, geologists with indifference, he gives a very long systematic catalogue of Miocene foraminiferal species in California. Even geologists, however, will heartily approve of the 22 plates of beautiful reproductions of Margaret Moore Hughes' wonderful drawings of Miocene *Foraminifera*.

To California geologists and paleontologists this volume is of course essential, even though most of them may disagree with certain conclusions or at least feel doubtful about them. To those who live elsewhere, the reviewer believes that the book will be only less useful. Troublesome as the local geographic and other details may prove to be, there is so much sound or at least illuminating discussion of fundamental stratigraphic problems as to justify mastering the details.

In spite of any defects it may have, moreover, many of us suspect that Kleinpell's book is of the kind called epoch-making. If so, in 50 or 100 years it will stand out like a beacon among its contemporaries and, along with a very few others of them, will read with a "modern" tang. Oppel's "Die Juraformation," or Suess' "Die Entstehung der Alpen," or to go back to the beginning, De Saussure's "Les Voyages dans les Alpes" may be cited among older geological classics that are now distinguished by this same tang.

RALPH D. REED.

NOTICE

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THE SOCIETY has in stock at the headquarters in Tulsa, Oklahoma, a large number of separate copies of plates which have appeared in the JOURNAL OF PALEONTOLOGY from Volume 4, Number 3 to Volume 11, Number 3. Persons desiring copies of these plates may obtain them from the Society of Economic Paleontologists and Mineralogists, Box 979, Tulsa, Oklahoma at the following prices:

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ERRATUM

The following correction should be made in the paper by Dr. Chalmer L. Cooper on "Conodonts from a Bushberg-Hannibal Horizon in Oklahoma" which appeared in the Journal of Paleontology, Volume 13, Number 4: The plat above the section (top of page) should read Tps. 2 and 3 N., Rs. 6 and 7 E., instead of Tps. 7 and 8 N., Rs. 5 and 6 E.

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